



**DEPARTMENT OF THE NAVY**  
NAVAL FACILITIES ENGINEERING COMMAND, MID-ATLANTIC  
9742 MARYLAND AVENUE  
NORFOLK, VA 23511-3095

5090  
EV3/07/225

Michael A. Mintzer  
Assistant Regional Counsel  
New York/Caribbean Superfund Branch  
Office of Regional Counsel  
U.S. Environmental Protection Agency,  
Region II  
290 Broadway, 17<sup>th</sup> Floor  
New York, NY 10007-1866

SUBJECT: NEWTOWN CREEK SUPERFUND SITE, KINGS COUNTY AND QUEENS COUNTY,  
NEW YORK, REQUEST FOR INFORMATION PURSUANT TO THE  
COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND  
LIABILITY ACT (CERCLA), 42 U.S.C. §§ 9601-9675

Dear Mr. Mintzer:

This letter responds to the Environmental Protection Agency's CERCLA § 104(e) letter dated November 10, 2011 requesting information from the Navy regarding its historic operations at the Brooklyn Navy Yard, Maspeth Annex and Newtown Creek. EPA requested responses to questions concerning the Navy's ownership and operations, its arrangements with other entities concerning the site, and information related to any leaks, spills, discharges, etc. occurring at the Annex. EPA also requested copies of documents pertaining to activities of the Navy at this location, such as contracts, leases, permits, reports, etc. Your e-mail dated December 15, 2011, extended our original response deadline to January 31, 2012.

Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic and other NAVFAC components do, as part of their Environmental Restoration program responsibilities, collect information regarding past waste disposal practices, spills, and other contamination-related issues at Naval installations, for purposes of conducting clean-ups under CERCLA and the Resource Conservation and Recovery Act (RCRA). We therefore contacted various NAVFAC component organizations to determine whether any of them possessed any relevant records, or knew of any employees, past or present, who might have information about Navy activities at or near the Maspeth Annex. We also contacted Navy Sea Systems Command; Commander, Navy Region Mid-Atlantic; Military Sealift Command; and the Office of Naval Research (ONR) to determine if any of those entities might have information relevant to this request.

The Navy found no employees with any personal knowledge of Navy activities at Maspeth Annex or any knowledge of former employees who might have such information. However, our search located several documents which are attached to this response. Substantive responses to EPA's questions, to the extent the Navy was able to provide them, are also attached.

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Two sources of potentially responsive documents were received or discovered this week and are currently under review. First, multiple boxes requested from National Records Center were received by ONR during the week of January 23, 2012 and are in the process of review. Nine boxes have been reviewed and 38 remain for review. The majority of the boxes contain classified material and all boxes and documents are in a deteriorated state. Review and possible production of documents presents challenges. It is anticipated that the review of these boxes will be completed by February 1<sup>st</sup>. This response will be supplemented as soon as possible to address any responsive information found in these sources.

Second, an additional file folder containing a list of Office of Naval Research contracts dating back to approximately 1946 was located this week. It is unclear whether the contract records associated with the list still exist. The list does not contain "accession numbers" needed for archival retrieval. However, some contracts on the list contain "job numbers" that can possibly be cross-referenced to identify a possible accession number. The records associated with the identified accession numbers would then have to be ordered from the Washington National records Center and reviewed. It is anticipated that this process may take a month or more and the response will be supplemented as soon as possible to address any responsive information found.

Please note that the Navy manages its records pursuant to the policies contained in SECNAVINST 5210.8D (Dec. 31, 2005) and SECNAV Manual 5210.1 (Nov. 2007, incorporating Change 1, Sept. 2009). For contract related records, the Navy also follows the Federal Acquisition Regulation (FAR) section 4.805 requirements for contract documentation retention periods. Because of the age of the information being sought, such records most likely would have been destroyed some time ago or transferred to the National Archives and Record Administration (NARA). Relevant excerpts from Department of the Navy, Records Management Program, Records Management Manual [SECNAV M-5210.1] are enclosed.

If the Navy locates additional or different information, we will promptly notify EPA. If you require additional information or clarification, I am the Navy's technical point of contact and may be reached at (757)341-0392. The Navy's legal point of contact is Katherine Will, who may be reached at (757)341-2106.

Sincerely,



Robert G. Schirmer  
Environmental Restoration  
Product Line Coordinator  
By direction of the  
Commanding Officer

Enclosures:

Response to EPA Questions  
Response to EPA Question 43  
Certification of Answers to Request for Information  
Excerpts from SECNAV M-5210.1  
Documents Found

Copy to:

Caroline Kwan, Remedial Project Manager  
Michael Hayes, Navy Litigation Office

# REQUEST FOR INFORMATION

## Section 1.0 Future Communications from EPA

1. Future EPA Communications: If the Navy requests that future communications from EPA regarding the Site be sent to a particular individual or office, provide the name, address, telephone number, e-mail address and capacity of such individual or office.

Navy Response:

Future communications regarding the Site should be sent to:

Mr. Robert Schirmer  
Environmental Restoration  
Product Line Coordinator  
Naval Facilities Engineering Command,  
Mid-Atlantic  
9742 Maryland Avenue  
Norfolk, VA 23511  
757-341-0392  
[Robert.g.schirmer@navy.mil](mailto:Robert.g.schirmer@navy.mil)

## Section 2.0 Owner/Operator Information

2. Identify the Navy's ownership, custody and/or control of the Facility, including:

a. Nature of the Navy's interest in the Facility between 1943 and 1959;

b. Dates of acquisition and date of disposition of the Navy's interest and identity of the non-Navy or Navy predecessor transferor (on or about 1943) and transferee (on or about 1959);

c. Describe the different roles and responsibilities of the Navy during periods when the Facility was used by the Navy but when ownership or control was vested in others (e.g., Reconstruction Finance Corporation, Defense Plant Corporation or General Services Administration);

d. Dates of operation and date of cessation of operation of the Facility; and

e. Provide a copy of all instruments evidencing the acquisition or conveyance of the Navy's interest in the Facility (e.g., permits, leases, licenses, intra-governmental memoranda of understanding, etc.). (see attachment pages NEWT 00041552 - 00041557, NEWT 0041557 and NEWT 0041862 - 0041163 for reference to leases and permits to the Navy).

Navy Response:

Encl. 1

The Navy located a New York Times news article dated September 8, 1945 indicating that the Reconstruction Finance Corporation had previously cancelled its lease on the aluminum smelting plant located at Maspeth, N.Y. Another New York Times news article dated September 25, 1945 indicated that the Navy's Bureau of Ships planned to retain the Brooklyn Navy Yard's Maspeth Annex for "industrial activities" following the war. A third New York Times news article dated December 25, 1947 indicated that the Navy had budgeted \$5,000,000 to buy the Maspeth Annex which was at the time leased for \$163,000 per year.

The Navy also located two agreements that appear to pertain to the Maspeth Annex. The first is an agreement between the Bohack Realty Corporation and the U.S. and dated December 1, 1942 allowing the Navy's Bureau of Yard and Docks permission to use Bohack's boat basin for the purposes of "compensating PT boat compasses, landing barges and other small naval craft." The second agreement, dated September 7, 1945, between the Long Island Rail Road Company and the U.S. allowed the Navy to use two of the Rail Company's existing sidetracks and switch connections. The agreement indicated that it vested ownership of one of the sidetracks in the Navy.

The news articles and agreements are attached to this response. The agreement with Bohack Realty Company references an attachment, but no attachment was located with the document found. No other information or documents were located responsive to this question.

**3. Identify all entities to whom the Navy granted rights to the Facility or to any portions thereof, or from whom the Navy derived rights to the Facility or any portion thereof, including a description of such arrangements, and provide a copy of all instruments evidencing or describing such arrangement including, but not limited to, the following:**

- a. Lessees, sublessees, licenses, or holders of easements (see, e.g., attachment page NEWT 0020182, which refers to a lease to the Government from the Long Island Railroad, which is renewed pursuant to the subject attachment).**
- b. Contractors, subcontractors, licensees or licensors that exercised control over any materials handling, storage, or disposal activity.**
- c. Pipelines providing delivery of materials to, distribution within or shipment from the Facility;**
- d. Railroads or rail lines providing delivery of materials to or shipment from the Facility;**
- e. Barge or other shipping companies providing delivery of materials to or shipment from the Facility; and**
- f. Governmental agencies, departments or instrumentalities other than the Navy. (see, e.g., question number 7, below).**

Navy Response:

As indicated above, two agreements were located that appear to relate to the Maspeth Annex. The first is an agreement between the Bohack Realty Corporation and the U.S. and dated December 1, 1942 allowing the Navy's Bureau of Yard and Docks permission to use Bohack's boat basin for the purposes of "compensating PT boat compasses, landing barges and other small naval craft." The second agreement, dated September 7, 1945, between the Long Island Rail Road Company and the U.S. allowed the Navy to use two of the Rail Company's existing sidetracks and switch connections. The agreement indicated that it vested ownership of one of the sidetracks in the Navy.

Both agreements are attached to this response. No other information or documents were located responsive to this question.

**4. Ownership of Newtown Creek: At the present time or at any past time, has the Navy or the United States on behalf of the Navy:**

- a. Owned any portion of Newtown Creek or wetlands associated with Newtown Creek?**
- b. Asserted control or exclusive rights to use any area of Newtown Creek or wetlands associated with Newtown Creek, for any purpose including, without limitation, dredging, filling, construction, maintenance or repair of any facility located in the waters, the associated wetlands or sediment including, by way of example, bulkheads, rip rap, pipes, wharfs, piers, docking, loading or unloading facilities, cranes or over-water facilities?**
- c. If the answer to either subparagraph "a" or "b" of this paragraph is yes, please identify the areas owned or controlled, or over which the Navy has a right to use, provide an explanation of how and from whom the Navy acquired such ownership or control, provide a copy of all title documents, leases, permits or other instruments where such right was derived, and describe all activities conducted pursuant thereto.**

Navy Response:

The Navy located no documents or information responsive to this question.

**5. Operations In, Under or Over the Waters or On the Sediments of Newtown Creek:**

- a. Describe all activities at the Facility that were conducted over, on, under, or adjacent to, Newtown Creek. Include in your description whether the activity involved hazardous substances, industrial waste, petroleum or other waste materials and whether any materials were ever discharged, spilled, disposed of, dropped, or otherwise came to be located in Newtown Creek.**

b. Has the Navy, at any time, constructed or operated any facility in or over the waters or on the sediments of Newtown Creek, including any bulkheads, rip-rap, pipes wharfs, piers, docking, loading or unloading facilities, containment booms, cranes or other on-water or over-water facilities?

c. Has the Navy, at any time constructed, operated or utilized any facility under the waters or sediments of Newtown Creek, including without limitation pipes, pipelines, or other underwater or under sediment facilities?

d. If the answer to subparagraph "b" or "c" of this paragraph is yes, please provide details including the facilities constructed or operated, the dates of such construction, replacement or major modification; whether there were discharges into the waters of Newtown Creek associated with construction or maintenance of such facilities, all permits associated with the construction or operation and the nature of the Navy's authorization to construct or maintain such facilities in Newtown Creek including from whom the operating rights were obtained, and provide copies of relevant deeds, leases, licenses and permits.

e. Provide a summary of over-water activities conducted at the Facility, including but not limited to, any material loading and unloading operations associated with vessels, materials handling and storage practices, ship berthing and anchoring, ship fueling, cleaning, maintenance, or repair.

f. Has the Navy utilized lighters, barges, tankers or other vessels ("vessels") in any operations on Newtown Creek and, if so, provide details? With respect to vessel operations,

i. Identify all products and raw materials transferred to or from vessels and the dates of such operations;

ii. Describe the method of transfer to and from vessels during all periods of such activities;

iii. Identify the types of vessels utilized, the location at the Facility where vessels were moored and describe the docking and mooring facilities at the Facility;

iv. Describe vessel repair or maintenance activities, if any;

v. Describe vessel cleaning operations, if any, including the cleaning methods that were used, how cleaning waste was handled; and

vi. Describe spill prevention controls that were utilized in delivery or pick-up of materials.

g. State whether any of the operations required to be identified above resulted in disposal or spillage of any materials into Newtown Creek or the re-suspension of any sediments of Newtown Creek. If the answer is a "yes" please provide details and documentation of such events.

Navy Response:

As indicated above, the Navy located an agreement between the Bohack Realty Corporation and the U.S. and dated December 1, 1942 allowing the Navy's Bureau of Yard and Docks permission to use Bohack's boat basin for the purposes of "compensating PT boat compasses, landing barges and other small naval craft." No other information or documents were located responsive to this question.

**6. Litigation and Administrative Enforcement:**

**a. Has the United States, on behalf of the Navy, been a party to any litigation, whether as plaintiff or defendant, where an allegation included liability for contamination of or from the Facility, any Other Newtown Creek Property within 1,000 feet of Newtown Creek (whether or not owned or operated by the Navy)? If yes, identify such litigation and its disposition, briefly describe the nature of the Navy's involvement in the litigation and provide a copy of the pleadings and any final order.**

**b. Has the United States, on behalf of the Navy, been identified by the EPA or by any New York State or New York City agency as a party responsible for environmental contamination with respect to a facility located within 1,000 feet of Newtown Creek? If yes, state the Navy's understanding of the basis for such notice of responsibility and provide a copy of any correspondence, orders or agreements between the Navy and the governmental agency.**

Navy Response:

The Navy located no documents or information responsive to this question.

**7. EPA understands that in April 1949, the Navy issued permit Number NOy(R) 44383 to the Atomic Energy Commission for the use by the Atomic Energy Commission of certain land at the Facility including the use of buildings 42, 43, 43.a and 48 at the Facility. Please state whether the Atomic Energy Commission took possession of the permitted space, and the term of the permit. Please identify the activities undertaken by the Atomic Energy Commission at the Facility and the nature of wastes resulting from those activities and the methods of waste disposal. Please provide a copy of the permit and of all written materials relating to the occupation and use of the Facility by the Atomic Energy Commission. In order to facilitate your response to this question, enclosed with this Request for Information is a copy of correspondence between the Navy and the United States Corps of Engineers relating to the permitted use of the Facility by the Atomic Energy Commission. (see attachment pages 0020157 - 0020160).**

Navy Response:

The Navy located no documents or information responsive to this question.

**8. Identify each and every Other Newtown Creek Property (see Definition number 9.b for "Other Newtown Creek Property") that the Navy presently (or previously) owns (or owned), leases (or leased), manages (or managed), operates (or operated), controls (or controlled), or otherwise has or**

had rights to use, manage or operate within the area extending one-thousand feet from the shoreline of Newtown Creek (Definition number 1 above defines "Newtown Creek" to include all tributaries or branches of Newtown Creek).

Navy response:

Other than the two agreements identified in previous responses, the Navy located no documents or information responsive to this question.

### **Section 3.0 Description of the Facility**

**9. Provide the following information for the Facility, including a description responsive to each question and depictions by map, drawing, survey or otherwise:**

- a. historic photographs, including without limitation, aerial photographs, photographs showing construction, industrial or commercial processes, sanitary and storm sewer systems, outfalls, indoor and outdoor storage of materials or products, and photographs during construction;**
- b. all surveys and drawings of the Facility in your possession showing configurations of the Facility;**
- c. sanitary sewer system information, including drawings, sewer easements, surveys or maps showing location and configuration of sewer systems;**
- d. storm water sewer system information, including drawings, surveys or maps showing location and configuration;**
- e. all below-ground structures, including, pipes, pipelines, sumps, wells, dry-wells and other structures for storage or conveyance of solid, gaseous or liquid materials, whether above ground or below ground, and whether owned or operated by you or by another;**
- f. all above-ground structures, including buildings and including all facilities for storage or transport of solid, liquid or gaseous materials, whether owned or operated by you or by another;**
- g. all over-water or in-water facilities (e.g., piers, docks, cranes, bulkheads, pipes, treatment facilities, containment booms, etc.);**
- h. all treatment or control devices for all media and pursuant to all environmental laws and regulations (e.g., surface water, air, groundwater, hazardous waste, solid waste, etc.);**
- i. groundwater wells, including drilling logs;**

**j. information related to any other outfalls, ditches, direct discharge facilities or other conveyance features and any discharges associated therewith; and**

**k. for all items identified in subparagraphs c, d, e, f, g, h, i, or j, locate each such item on a Facility map or plan, provide the date of installation, identify all permits associated with each item, state whether such items are still in service or, if not, when they were removed from service, identify all leaks or spills, if any, associated with each, and identify any closure of any such item.**

Navy Response:

Other than the attachment to the agreement with Long Island Rail Road Company depicting rail tracks and sidings, the Navy located no documents or information responsive to this question.

**10. For each environmental permit issued with respect to the Facility during the Navy's period of ownership or operation, identify the type of permit, the agency or governmental authority issuing the permit and provide a copy of the permit, the permit application, and any reports required to be generated by the permit.**

Navy Response:

The Navy located no documents or information responsive to this question.

**11. With regard to the placement of fill at the Facility:**

**a. Was any fill placed on the Facility during the development or redevelopment of the Facility by the Navy, or at any time thereafter? If so, identify all areas of the Facility where fill was placed, the lateral extent of the fill and the depth of the fill, the purpose of the placement, the source of the fill, the amount of the fill in each area, and the identity of the contractors involved in work related to the fill. State whether the fill has ever been characterized, either before placement or thereafter and, if so, provide a copy of the sampling/characterization results.**

**b. Were any portions of the Facility historically part of Newtown Creek or did the Facility formerly include any marshlands or wetlands associated with Newtown Creek. Please depict any such areas on a survey, drawing or schematic. Please provide your understanding of who filled any such wet areas, the approximate date of such fill, and the lateral extent and depth of such fill, the source of the fill, the composition of the fill and, if any sampling has ever been done of such filled areas, provide a copy of the sampling results.**

Navy Response:

The Navy located no documents or information responsive to this question.

**12. Provide a copy of all reports, information or data you have related to soil, water (ground and surface), or air quality and geology/hydrogeology at and about the Facility. Provide copies of all documents containing such data and information, including both past and current aerial photographs as well as documents containing analysis or interpretation of such data.**

Navy Response:

The Navy located no documents or information responsive to this question.

**13. Identify all past and present solid waste management units or areas where materials are or were in the past managed, treated, or disposed (e.g., waste piles, landfills, surface impoundments, waste lagoons, waste ponds or pits, drainage ditches, tanks, drums, container storage areas, etc.) on the Facility. For each such unit or area, provide the following information:**

**a. a map showing the unit/area's boundaries and the location of all known units/areas whether currently in operation or not. This map should be drawn to scale, if possible, and clearly indicate the location and size of all past and present units/areas;**

**b. dated aerial photograph of the Site showing each unit/area;**

**c. the type of unit/area (e.g., storage area, landfill, waste pile, etc.), and the dimensions of the unit/area;**

**d. the dates that the unit/area was in use;**

**e. the purpose and past usage (e.g., storage, spill containment, etc.);**

**f. the quantity and types of materials (hazardous substances and any other chemicals) located in each unit/area;**

**g. the construction (materials, composition), volume, size, dates of cleaning, and condition of each unit/area; and**

**h. If the unit/area described above is no longer in use, explain how such unit/area was closed and what actions were taken to prevent or address potential or actual releases of waste constituents from the unit/area.**

Navy Response:

The Navy located no documents or information responsive to this question.

**14. Provide the following information regarding any current or former sewer or storm sewer**

lines or combined sanitary/storm sewer lines, drains, or ditches discharging into Newtown Creek from the Facility:

- a. the location and nature of each sewer line, drain, or ditch;
- b. the date of construction of each sewer line, drain, or ditch;
- c. whether each sewer line, drain, or ditch drained any hazardous substance, waste, material or other process residue to Newtown Creek; and
- d. provide any documentation regarding but not limited to the following on any and all outfalls to Newtown Creek which are located within the boundaries of the Facility. Your response should include, but not be limited to:
  - i. whether the Facility is serviced by or otherwise drains or discharges to the outfalls and, if so, the source of the outfall;
  - ii. the identify of upland facilities serviced by the outfalls;
  - iii. the upland geographic area serviced by the outfalls; and
  - iv. the type of outfall (i.e., storm water or single or multiple facility outfall).

Navy Response:

The Navy located no documents or information responsive to this question.

**15. Provide copies of any storm water or Facility drainage studies, including data from sampling, conducted at these Properties on storm water, sheet flow, or surface water runoff. Also provide copies of any storm water pollution prevention, maintenance plans, or spill plans developed for different operations during the Navy's operation of the Facility.**

Navy Repsonse:

The Navy located no documents or information responsive to this question.

**16. Sewer Infrastructure including double barrel sewer: Provide the following information regarding sewer or storm sewer lines or combined sanitary/storm sewer lines, drains, or ditches discharging into Newtown Creek from the Facility, including specifically, and without limitation, the double barrel sewer draining into Maspeth Creek from the Facility (see attachment page NEWT 0004301 showing location of double barrel sewer at the Facility);**

- e. the location and nature of each sewer line, drain, or ditch;
- f. the date of construction of each sewer line, drain, or ditch;

- g. identify and provide copies of all sewer easements affecting the Facility;**
- h. identify all drains at the Facility, interior and exterior, that were tied in to the double barrel sewer, and identify the processes producing wastes that were disposed of through connections to the double barrel sewer;**
- i. whether each sewer line, drain, or ditch drained any hazardous substance, waste, material or other process residue to Newtown Creek; and**
- j. provide documentation regarding but not limited to the following on any and all outfalls to Newtown Creek which are located within the boundaries of the Facility. Your response should include, but not be limited to:**
  - v. whether the Facility is serviced by or otherwise drains or discharges to the outfalls and, if so, the source of the outfall;**
  - vi. the identify of upland facilities serviced by the outfalls;**
  - vii. the upland geographic area serviced by the outfalls; and**
  - viii. the type of outfall (i.e., storm water or single or multiple facility outfall).**

**Navy Response:**

The Navy located no documents or information responsive to this question.

**17. Connections to New York City sewer system (see attachment page NEWT 0020035):**

- a. State whether the Facility was connected to the New York City sewer during the Navy's ownership or operation, and the date that the Facility was first connected;**
- b. State whether the Facility has ever discharged liquid wastes other than through the New York City sewer system and, if so, provide details on such discharges;**
- c. State whether the Facility participated in the New York City pretreatment program, whether the Navy has ever been classified as a significant industrial user, whether the Navy has ever been in violation of sewer use requirements or permits or received any notices of violation relating to use of the New York City sewer system;**
- d. Provide any information detailing the volume of liquids discharged to the sewers and the nature of the discharges including analytical data detailing the makeup of the discharged liquids;**

- e. Provide copies of all permits and permit applications for Industrial Wastewater discharge permits;
- f. Provide copies of all notices of violations, correspondence, hearing transcripts and dispositions relating to the Navy's use of the New York City sewer system;
- g. Copy of Baseline Monitoring Reports submitted to NYC in connection with the Navy's application for an industrial wastewater discharge permit;
- h. Copies of all surveys, reports or analyses delineating or characterizing the Navy's liquid wastes;
- i. Copies of all periodic monitoring reports for wastes discharged through the sewer system;
- j. Copies of all invoices from NYC or the NYC Water Board for water and/or wastewater charges including any wastewater allowances.

Navy Response:

The Navy located no documents or information responsive to this question.

## Section 4.0 Navy's Operational Activities

18. Provide a detailed description of activities conducted by the Navy (or by other United States Government instrumentalities acting pursuant to permit, lease or other right granted by the Navy). If the products, processes, operation, or business activity changed over time, please identify each separate operation or activity, the dates when each operation or activity was started and, if applicable, ceased. Please address all activities conducted at the Facility including, without limitation:

- a. Storage of 30,000 tons of NSA (and identify what "NSA" refers to (see attachment page NEWT 0041555)), storage of 60,000 tons of coal (see attachment page NEWT 0041555 and NEWT 0004315), storage of scrap including identification of the scrap materials (see attachment page NEWT 0004315), salvage and reconditioning, storage of salvage material removed from various building at the Facility (see attachment page NEWT 0004315);
- b. Reconditioning of guns, ordnance and other equipment and processing diesel engine parts (see attachment page 0004236 and NEWT 004220);
- c. Activities in connection with operation of the US Naval Shipyard: Brooklyn, NY Maspeth annex (see, e.g. attachment page NEWT 0004436);

**d. Garage and automotive service and repair activities in building 45 at the Facility (see attachment page NEWT 0004315 and pages NEWT 0004538 – 0004539 (Building 45));**

**e. Activities conducted by other Governmental agencies, including without limitation, the Atomic Energy Commission (see question number 7, below);**

**f. Ship building or vessel maintenance activities, if any; and**

**g. All other activities conducted by the Navy or by others during the time that the Navy had custody or control of otherwise owned or operated the Facility.**

Navy Response:

The Navy located several documents providing general information regarding activities conducted at the site. These documents are attached to this response. The Bureau of Ordnance, Guns and Mounts No. 75 document indicates that a small arms repair shop existed at Maspeth Annex. The document further indicates that “these shops were equipped to complete major overhaul, inspection, and packaging.” The New York Times article of September 25, 1945 indicates that the Navy intended to retain the Maspeth Annex following the war for “industrial activities.” The New York Times article of December 25, 1947 indicates that the Navy was, at that time, using the property as a storage depot. The article further indicates that two aluminum smelting plants were present on the site. A New York Times news article of February 10, 1948 indicates that the Navy supplied emergency diesel oil for the public during a heating oil crisis. One of the depots where oil was “poured into police certified trucks” was “the Maspeth terminal of the Sylvestre Oil Company.”

Further, one of the two agreements discussed in earlier responses indicated that the Navy had the right to use the Bohack Realty Corporation’s boat basin for the purposes of “compensating PT boat compasses, landing barges and other small naval craft.” The second agreement with the Long Island Rail Road Company indicated that the Navy had the right to use two of the Rail Road Company’s existing sidetracks and switch connections. It is unclear from these agreements when or if these activities started or when they ceased.

Finally, while not specifically conducted at the site, it appears that the Navy sponsored a research project (Project Whirlwind) at the Massachusetts Institute for Technology (MIT) that was connected with the Maspeth Annex. The Office of Naval Research (ONR) replaced the Office of Research and Inventions (ORI) in 1946. Project Whirlwind began sometime during World War II as an ORI sponsored project and was completed in 1951 under ONR sponsorship according to internet sources. According to Project Whirlwind Summary Report No. 1, the project involved “a program of research, investigation and development in the field of high-speed electronic digital computation.” The project was “specifically aimed at the solution of aircraft stability and control problems” and “was organized in December 1944.”

According to a partial index of possible archive holdings at MIT obtained from the internet, MIT may be in possession of records or documents related to Project Whirlwind. Some index entries suggest that correspondence may exist regarding the use of surplus material for the project that was available at the Maspeth Annex. A CD containing the complete summary report of the project, as well as a hard copy portion of the report and a partial index of possible archive holdings held at MIT is attached to this response.

Aside from the information identified above, no other information or documents have currently been located responsive to this question. As stated in the cover letter however, additional potential sources of information related to this question have recently been located and are in the process of review. The response will be supplemented to address any additional information found.

**19. Attachment pages NEWT 0004538 - 0004540 appears to show "Department and Division" and "Use" of a number of buildings at the Facility "showing condition on June 30, 1945." Attachment pages NEWT 0004312 - 0004318 provides further details of building usage as of May 1947. Please identify the responsibilities of the following Departments and Divisions and describe in detail the following uses, including chemicals used in such activities, solid and liquid waste streams, connections to sewers for liquid wastes and waste disposal:**

Department and Division	Use
Industrial Ordnance	Salvage and Reconditioning
Industrial Ordnance	Heavy Ordnance
Industrial Ordnance	Inspection & Assembly Including Small Arms
Industrial Ordnance	Reconditioning Assembly and Inspection
Industrial Production	Internal Combustion Engine: Salvage and Reconditioning
Industrial Production	Special Industrial Assignments
Supply	Supply Functions at Maspeth
Supply	Receiving and Shipping
Public Works	Garage & Oil Storage
Public Works	Boiler House

Navy Response:

The Navy located no documents or information responsive to this question.

**20. Did the Navy store or combust coal at the Facility during the time of its ownership or operation? If your answer is yes, please respond to the following requests for information for all periods of time that the Navy operated at or owned the Facility (please refer to attachment page NEWT 0041555 concerning storage of coal and attachment page 0004540 containing Facility map depicting large coal storage area adjacent to Newtown Creek):**

- a. Identify the purposes for such coal storage or combustion, including if used in energy production, the processes in which the energy was used at the Facility;
- b. State the means by which the shipments of coal were delivered to the Facility, whether by barge, rail, truck or other, and identify the shipper and the vendor. Describe how the coal was received at the Facility and transported to storage facilities;
- c. Identify the volume of coal received at the Facility, the type or types of coal (i.e. bituminous, anthracite, etc.) received and consumed on an annual basis during the period of the Navy's ownership or operations, including changes over time;
- d. Describe the means of storage of coal at the Facility, including whether the Facility employed coal pockets or other storage areas, the dimensions and volume of such storage facilities, and whether such storage was indoors or outdoors and covered or uncovered. Identify on a Facility map or diagram the location of the coal storage facilities. Describe the means of transport of the coal from the storage facilities to the combustion point; and
- e. Identify how the coal ash was managed including the location and storage facilities for the coal ash, and whether indoors or outdoors, covered or uncovered, the means of conveying the ash to the on-site storage facilities, the location of the storage facilities, and, if sent for disposal, identify the disposal companies. State whether the ash was ever used at the Facility, whether as fill or for any other purpose, or otherwise disposed of at the Facility and, if it was describe the circumstances and identify the areas of disposal on a Facility map.

Navy Response:

The Navy located no documents or information responsive to this question.

**21. Describe the receipt and storage of chemicals, raw materials, intermediary product, fuel and final product at the Facility. For each question, identify the time period covered by your response. Please provide a copy of Navy manuals that over time were in effect describing these procedures. Please:**

- a. Identify chemicals acquired for use at the Facility including the identification of each such chemical, the purpose for which it was used and the method and location of use and storage at the Facility. Describe all processes for which each such chemical was used at the Facility. Please provide Material Data Safety Sheets (MSDSs) for each such chemical. Identify all spills, emissions, discharges and releases of any such substances at or from the Facility.
- b. Identify metals and metal compounds (including but not limited to raw materials, scrap, byproducts, ash, wastewater and wastes containing metals or metal compounds but not including metals as components of structures or equipment) acquired for use at the Facility and the method and

location of use and storage at the Facility. Please provide MSDSs for each such chemical. Identify all spills, emissions, discharges and releases of any such substances at or from the Facility.

c. For polychlorinated biphenyls (PCBs): identify any PCBs previously or currently used or otherwise present at the Facility including, but not limited to

(i) PCBs in plasticizers, fire retardants, paints, water-proofing, railroad ties, heat stabilizing additives for adhesives, and other materials;

(ii) PCBs in capacitors, transformers, vacuum pumps, hydraulic systems, and other devices; and

(iii) PCBs in raw materials, wastes, wastewater, scrap, and byproducts;

Identify the purpose for each of them, any PCB testing done on such materials, and the method and location of use, storage and other handling of PCBs at the Facility. Identify all spills, emissions, discharges and releases of any PCBs at or from the Facility. Please provide any MSDSs for PCBs at the Facility.

d. Provide copies of any records, including Navy manuals or written procedures that you have in your possession, custody or control relative to the activities described in this Question.

Navy Response:

Aside from the February 10, 1948 New York Times article indicating that the Navy provided heating oil to the public during a heating crisis, the Navy found no other information or documentation responsive to this question.

**22. For all periods of the Navy's ownership or operation of the Facility, describe how wastes transported off the Facility for disposal or treatment were handled, stored, and/or treated prior to transport to the disposal facility.**

Navy response:

The Navy located no documents or information responsive to this question.

**23. Describe the cleaning and maintenance of the equipment and machinery involved in operations at the Facility, including but not limited to:**

a. the types of materials used to clean/maintain this equipment/machinery;

b. the monthly or annual quantity of each such material used;

c. the materials used to clean up those spills;

d. the methods used to clean up those spills;

**e. where the materials used to clean up those spills were disposed of;**

**f. provide copies of Navy manuals or procedures relating to cleaning of equipment and machinery and the Facility; and**

**g. provide copies of all records of such cleaning and maintenance including internal records and records from any outside vendor for such services.**

Navy Response:

The Navy located no documents or information responsive to this question.

**24. Describe all wastes disposed by the Navy into drains at the Facility, including but not limited to:**

**a. the nature and chemical composition of each type of waste;**

**b. the approximate quantity of those wastes disposed by month and year;**

**c. the location to which these wastes drained (e.g. Facility drains to Newtown Creek, sheet flow to Newtown Creek, septic system or storage tank at the Facility, oil-water separator, pre-treatment plant, New York City sewer system); and**

**d. whether and what pretreatment was provided.**

Navy Response:

The Navy located no documents or information responsive to this question.

**25. Identify all oil/water separators at the Facility during the Navy's ownership or operation including dates of installation, dates of replacement or major modification, purpose of installation and source of influent, and location of discharge. Provide a copy of each permit and permit application, influent and effluent sampling results and copies of all submissions to federal, state, city or county environmental agencies or public health agencies relating to oil/water separators.**

Navy Response:

The Navy located no documents or information responsive to this question.

**26. Identify each fixed above-ground storage tank and each fixed below-ground storage tank that is or was situated on the Facility during the Navy's ownership or operation. For each tank, identify the date of installation, the dates and nature of major modifications, and description or drawings of tanks;**

identity of contents that have been stored in the tank both before (if known) or during the Navy's ownership or operation, and the practices of cleaning at the time of any change in items stored, and the manner of ultimate disposal of wastes from the tank. Identify procedures for addressing spills from the tanks and identify all spills that have occurred during the Navy's ownership of the Facility. Provide a copy of all permits relating to the tank and provide a copy of all Navy written manuals or procedures, including manuals that have been superseded by newer manuals or procedures, addressing use and maintenance of such tanks.

Navy Response:

The Navy located no documents or information responsive to this question.

**27. Identify each pipeline serving the Facility that is or was situated on the Facility property (either above- or below-ground) during the Navy's ownership or operation. For each pipeline, identify the owner and the operator for the pipeline servicing the Facility. If there are separate owners or operators of the pipeline for the segments located on the Facility and the segment located off the Facility, please identify all such owners and operators. Please provide a copy of all permits maintained by the Navy relating to the pipeline on the Facility and the date of installation. Please identify all materials transported to the Facility through the pipeline, including, without limitation, crude petroleum, petroleum products, additives, other refining materials, batch separators, natural gas, manufactured gas, other fuels, chemicals and/or other materials. Describe pipeline cleaning processes and procedures for handling and disposal of wastes in the pipelines including mixed batches of materials in the pipeline. Identify procedures for addressing spills from the pipelines and identify all spills that have occurred during the Navy's ownership or operation of the Facility. Please provide a copy of all Navy written manuals or procedures, including manuals that have been superseded by newer manuals or procedures, which address or regulated use and maintenance of such pipelines.**

Navy Response:

The Navy located no documents or information responsive to this question.

## **Section 5.0 Regulatory Information**

**28. Identify each federal, state and local authority that regulate or regulated environmental concerns relating to the ownership or operation at the Facility, the activity regulated, and the applicable federal, state and local statute or regulation from which such regulation was derived.**

Navy Response:

The Navy located no documents or information responsive to this question.

**29. Describe all occurrences associated with violations, citations, deficiencies, and/or accidents concerning the Facility related to environmental concerns. Provide copies of all documents associated with each occurrence described.**

Navy Response:

The Navy located no documents or information responsive to this question.

**30. Provide a list of all local, state and federal environmental permits which have been applied for or issued to the Navy with respect to the Facility for any media, e.g., water (including SPDES and NPDES, NYC sewer permit, Industrial Pretreatment Program permit or any other wastewater discharge related governmental authorization or notice), excavation and fill in navigable waters, dredging, tidal wetlands, air, solid waste or hazardous waste, bulk storage, industrial wastewater, etc. under any environmental statute or regulation. Provide a copy of each federal and state permit, the applications for each permit.**

Navy Response:

The Navy located no documents or information responsive to this question.

**31. Has the Navy or any contractor or agent associated with the Navy or any individual associated with any of the foregoing ever been accused of any criminal violation in connection with any operation at the Facility. If so, describe the disposition of such accusation and provide details on such accusation.**

Navy Response:

The Navy located no documents or information responsive to this question.

**32. Was a Notification of Hazardous Waste Activity ever filed with EPA or New York State for any activity at the Facility during the period that the Navy owned or operated at the Facility. If so, provide a copy of such notification and the response given by EPA or New York State including the RCRA identification number assigned.**

Navy Response:

The Navy located no documents or information responsive to this question.

**33. Identify all state or City offices to which the Navy has sent or filed hazardous substance or hazardous waste information with regard to the Facility or Other Newtown Creek Properties. State the years during which such information was sent/filed.**

Navy Response:

The Navy located no documents or information responsive to this question.

**34. Has the Navy or the Navy's contractors, lessees, tenants, or agents, ever contacted, provided notice to, or made a report to the New York State Department of Environmental Conservation or New York City Department of Environmental Protection or any other state or city agency concerning an incident, accident, spill, release, or other event involving the Facility or involving Newtown Creek? If so, describe each incident, accident, spill, release, or other event and provide copies of all communications between the Navy or its agents and NYSDEC, NYCDEP, NYSDOH, NYCDOH or any other state or city agency.**

Navy Response:

The Navy located no documents or information responsive to this question.

## **Section 6.0 Facility Releases, Investigations and Remediation**

**35. Identify all leaks, spills, or releases into the environment of any waste, including hazardous substances, pollutants, or contaminants, industrial waste or petroleum that have occurred at or from the Facility. In addition, identify and provide copies of any documents regarding:**

- a. the date of each releases;**
- b. how the releases occurred, e.g. when the substances were being stored, delivered by a vendor, transported or transferred (to or from any tanks, drums, barrels, or recovery units), and treated;**
- c. the identity of the material released and the amount of each released;**
- d. where such releases occurred;**
- e. activities undertaken in response to each such release or threatened release, including the notification of any agencies or governmental units about the release and the remediation and the regulatory disposition concerning such release; and**
- f. identify all fires, explosions or other similar events that have occurred at the Facility during the Navy's ownership or operation that required response either by a Facility employee or a New York City responder or that was the subject of a subsequent investigation by a New York City agency. Identify the location on a Facility map where each of the events occurred and identify the items that were combusted in whole or part, including, without limitation, hazardous substances, pollutants or**

**contaminants, industrial waste or petroleum. Provide a copy of all reports of the event, whether such reports are the Navy's private reports or are public reports in the Navy's possession.**

Navy Response:

The Navy located no documents or information responsive to this question.

**36. Was there ever a spill, leak, release or discharge of waste, or process residue, including hazardous substances; pollutants, contaminants, industrial waste; or petroleum, into any subsurface disposal system or floor drain inside or under a building on the Facility? If the answer to the preceding question is anything but an unqualified "no", provide details of each event and any communication with any federal, state or city regulatory body.**

Navy Response:

The Navy located no documents or information responsive to this question.

**37. Has any contaminated soil ever been excavated or removed from the Facility? If your answer is yes, identify and provide copies of any documents regarding:**

- a. reason for soil excavation;**
- b. location of excavation presented on a map or aerial photograph;**
- c. manner and place of disposal and/or storage of excavated soil;**
- d. dates of soil excavation and amount of soil excavated;**
- e. all analyses or tests and results of analyses of the soil that was removed from the Facility;**
- f. all confirmatory analyses or tests and results of analyses of the excavated area after the soil was excavated and removed from the area; and**
- g. all persons, including contractors, with information about (a) through (f) of this question.**

Navy Response:

The Navy located no documents or information responsive to this question.

**38. Have you treated, pumped, or taken any kind of response action on groundwater under the Facility? If your answer is "yes", identify and provide copies of any documents regarding:**

- a. reason for groundwater action;
- b. whether the groundwater contains or contained hazardous substances, pollutants, contaminants, industrial waste, or petroleum, what the constituents are or were which the groundwater contained, and why the groundwater contained such constituents;
- c. all analyses or tests and results of analyses of the groundwater;
- d. if the groundwater action has been completed, describe the basis for ending the groundwater action; and
- e. all persons, including contractors, with information about (a) through (d) of this question.

Navy Response:

The Navy located no documents or information responsive to this question.

**39. Was there ever a spill, leak, release or discharge of a hazardous substance, waste, or material into Newtown Creek from any equipment, structure, or activity occurring on, over, or adjacent to the Creek? If your answer is "yes", identify and provide copies of any documents regarding:**

- a. the nature of the hazardous substance, waste, or material spilled, leaked, released or discharged;
- b. the dates of each such occurrence;
- c. the amount and location of such release;
- d. whether sheens were created on the Creek by the release; and
- e. whether there ever was a need to remove or dredge any solid waste, bulk product, or other material from the Creek as a result of the release? If so, please provide information and description of when such removal/dredging occurred, why, and where the removed/dredged materials were disposed.

Navy Response:

The Navy located no documents or information responsive to this question.

**40. Describe the purpose for, the date of initiation and completion, and the results of any investigations of soil, water (ground or surface), sediment, geology, hydrology, or air quality on or about the Facility. Provide copies of all data, reports, and other documents that were generated by**

**the Navy or any contractor or consultant, or by a federal or state regulatory agency related to the investigations that are described.**

Navy Response:

The Navy located no documents or information responsive to this question.

**41. Describe any remediation or response actions that the Navy or its agents or consultants have ever taken or are currently taking at the Facility, either voluntarily or as required by any state, local or federal entity. If not otherwise already provided under this Information Request, provide copies of all enforcement agreements with regulatory agencies pursuant to which such response actions were undertaken as well as all reports of investigations or cleanup activities on the Facility.**

Navy Response:

The Navy located no documents or information responsive to this question.

**42. Provide a copy of all environmental investigation reports of the Facility including investigations undertaken at the times of acquisition and transfers of the Facility by the Navy.**

Navy Response:

The Navy located no documents or information responsive to this question.

## **Section 7.0 Compliance with this Request**

**43. Persons and Sources Consulted in Your Response: Identify all persons, other than counsel, that the Navy consulted, and all sources that the Navy reviewed in responding to this request, including, but not limited to:**

**a. the names of persons consulted, the contact information for such person, and if the person is a current or former employee, the job title and responsibilities for such persons and the dates of employment, and identify which questions the person was consulted about; and**

**b. a description and the location of where all sources reviewed are currently located and the questions to which such sources relate.**

Navy Response:

Please see attached document entitled "Response to Question 43."

**44. Identify all individuals who currently have and those who have had responsibility for the**

**Navy's environmental matters (e.g. responsibility for the disposal, treatment, storage, recycling, or sale of the Navy's wastes) at the Facility. Also provide each such individual's job title, duties, dates performing those duties, supervisors for those duties, current position or the date of the individual's resignation, and the nature of the information possessed by such individuals concerning the Navy's waste management.**

Navy Response:

No individual currently has such responsibility. The Navy located no other documents or information responsive to this question.

## **Response to Question 43**

**43. Persons and Sources Consulted in Your Response:** Identify all persons, other than counsel, that the Navy consulted, and all sources that the Navy reviewed in responding to this request, including, but not limited to:

- a. the names of persons consulted, the contact information for such person, and if the person is a current or former employee, the job title and responsibilities for such persons and the dates of employment, and identify which questions the person was consulted about; and
- b. a description and the location of where all sources reviewed are currently located and the questions to which such sources relate.

**Navy's Response:** In light of the age of the potential documents and information requested, the contacts listed below were consulted about all questions and the source locations listed below were reviewed for information related to all questions.

### **Persons Consulted:**

Rick Albert  
MSFSC, N7 Director of Engineering  
Military Sealift Fleet Support Command  
471 C Street, Bldg SP-64  
Norfolk, VA 23511  
757-443-5957  
[rick.albert@navy.mil](mailto:rick.albert@navy.mil)  
Date of employment: Current employee, May 2007 - present

David Allen  
N43A, Class Manager, Fleet Replenishment Oilers  
Military Sealift Fleet Support Command  
471 C Street, Bldg. SP-64  
Norfolk, VA 23511  
757-443-2760  
[david.g.allen1@navy.mil](mailto:david.g.allen1@navy.mil)

Claudio Azzaro  
N43E, Class Manager, MSC Special Mission Ships  
Military Sealift Fleet Support Command  
471 C Street, Bldg. SP-64  
Norfolk, VA 23511

757-443-2776  
[claudio.azzaro@navy.mil](mailto:claudio.azzaro@navy.mil)

Andy Busk  
N43C, Class Manager MSC, Dry Cargo/Ammunition Ships and High Speed Vessels  
Military Sealift Fleet Support Command  
471 C Street, Bldg. SP-64  
Norfolk, VA 23511  
757-443-2780  
[andrew.busk@navy.mil](mailto:andrew.busk@navy.mil)

Bonnie Capito  
Librarian and NARA Certified Records Manager  
Naval Facilities Engineering Command, Atlantic  
6506 Hampton Blvd.  
Norfolk, VA 23508  
757-322-4785  
[Bonnie.capito@navy.mil](mailto:Bonnie.capito@navy.mil)  
Dates of employment: Current employee, July 1993 – present

Roxanne Davis  
Realty Specialist  
Naval Facilities Engineering Command, Mid-Atlantic  
9742 Maryland Avenue  
Norfolk, VA 23511  
757-341-2002  
[Roxanne.davis@navy.mil](mailto:Roxanne.davis@navy.mil)  
Dates of employment: Current employee, September 2007 – present

Deidre D. Fisher  
Director of Contracts  
Military Sealift Fleet Support Command  
471 C Street, Bldg. SP-64  
Norfolk, VA 23511  
757-443-5877  
[Deidre.Rumsey-Fisher@navy.mil](mailto:Deidre.Rumsey-Fisher@navy.mil)  
Dates of employment: Current employee, July 1987 – present

Aaron Furman  
MSC Technical Library Director  
Military Sealift Fleet Support Command  
9276 Third Ave., Bldg. LP-26

Norfolk, VA 23511-2914

757-443-2627

[aaron.i.furman1@navy.mil](mailto:aaron.i.furman1@navy.mil)

Dates of employment: Current employee, July 2011 – present

Stephanie Harvey

Contract Closeout Specialist

Office of Naval Research

875 North Randolph Street

Arlington, VA 22203

703-696-4524

[Stephanie.harvey.ctr@navy.mil](mailto:Stephanie.harvey.ctr@navy.mil)

Dates of employment: Current ONR Contractor with 23 years experience

Brian Helland

Remedial Project Manager

BRAC Program Management Office Northeast

4911 South Broad Street

Philadelphia, PA 19112

215-897-4912

[Brian.helland@navy.mil](mailto:Brian.helland@navy.mil)

Dates of employment: Current employee, 1986 – present

Mark Helmkamp

N43D, Class Manager, MSC Ocean Tug and Salvage Ship

Military Sealift Fleet Support Command

471 C Street, Bldg. SP-64

Norfolk, VA 23511

757-443-2780

[mark.helmkamp@navy.mil](mailto:mark.helmkamp@navy.mil)

Dates of employment: Current employee, October 2008 – present

Alma Henry

Supervisory Architect,

Acting Asset Management Business Line Team Leader

Naval Facilities Engineering Command, Mid-Atlantic

9742 Maryland Avenue

Norfolk, VA 23511

757-341-1984

[Alma.henry1@navy.mil](mailto:Alma.henry1@navy.mil)

Dates of employment: Current employee, September 1983 - present

Andrea Hicks

NAVSEA Records Officer

Naval Sea Systems Command

1333 Issac Hull Avenue, S.E.

Washington Navy Yard, DC 20376

202-781-2466

[Andrea.hicks@navy.mil](mailto:Andrea.hicks@navy.mil)

Dates of employment: Current employee, February 2010 – present

Stephen Hoffman

Director, PMO-IT,

IT Manager for Shipyards

Naval Sea Systems Command

1333 Issac Hull Avenue, S.E.

Washington Navy Yard, DC 20376

202-781-3377

[Stephen.g.hoffman@navy.mil](mailto:Stephen.g.hoffman@navy.mil)

Dates of employment: Current employee, July 1985 - present

Tonya Kilgore

ONR Records Manager

Office of Naval Research

875 North Randolph Street

Arlington, VA 22203

703-696-4623

[Tony.kilgore@navy.mil](mailto:Tony.kilgore@navy.mil)

Dates of employment: Current employee, past 16 years

Thomas Klima

SEA 04XI, Installations and Equipment

Infrastructure Management and Shipyard Oversight

Naval Sea Systems Command

1333 Issac Hull Avenue, S.E.

Washington Navy Yard, DC 20376

202-781-1598

[Thomas.klima@navy.mil](mailto:Thomas.klima@navy.mil)

Dates of employment: Current employee, October 1980 – present

Matthew Kurtz

Product Line Coordinator, Real Estate Contracting Officer

Naval Facilities Engineering Command, Mid-Atlantic

9742 Maryland Avenue

Norfolk, VA 23511

757-341-0283

[Matthew.kurtz@navy.mil](mailto:Matthew.kurtz@navy.mil)

Dates of employment: Current employee, January 1989 – present

Fred McKenna

Deputy Director

Military Sealift Fleet Support Command

U.S. Navy's Military Sealift Command

471 C Street, Bldg SP-64

Norfolk, VA 23511

757-443-2702

[Fred.mckenna@navy.mil](mailto:Fred.mckenna@navy.mil)

Stephanie Montgomery

Archival Specialist

Washington National Records Center

4205 Suitland Road

Suitland, MD 20746

(301)778-1587

[Stephanie.montgomery@nara.gov](mailto:Stephanie.montgomery@nara.gov)

Diana Nichols-Gilchrist

Contract Closeout Specialist

Office of Naval Research

875 N. Randolph Street

Arlington, VA 22203

(703)696-2573

[Diana.nicholsgilchri.ctr@navy.mil](mailto:Diana.nicholsgilchri.ctr@navy.mil)

Dates of Employment: Contractor with 38 years experience

Arlyn Penaranda

Enterprise Records Management Assistant

Military Sealift Command

914 Charles Morris Court, SE

Washington Navy yard, 20398-5540

202-685-5308

[Arlyn.penaranda@navy.mil](mailto:Arlyn.penaranda@navy.mil)

Dates of employment: Current employee, June 2010 - present

Ryan Pierce

Realty Specialist

Naval Facilities Engineering Command, Mid-Atlantic  
9742 Maryland Avenue  
Norfolk, VA 23511  
757-341-2000  
[Ryan.t.pierce@navy.mil](mailto:Ryan.t.pierce@navy.mil)  
Dates of employment: Current employee, August 2006 - present

Michael Ricci  
N43B, Class Manager, T-AE / T-AOE & T-AGM 25  
Military Sealift Fleet Support Command  
471 C Street  
Norfolk, VA 23511  
757-443-2761  
[michael.ricci1@navy.mil](mailto:michael.ricci1@navy.mil)  
Dates of employment: Current employee, February 1987 - present

Linda Rucker  
Business/Financial Manager  
NAVSEA Liaison for Environmental, Safety and Health Programs  
Naval Sea Systems Command  
1333 Issac Hull Avenue, S.E.  
Washington Navy Yard, DC 20376  
202-781-1807  
[Linda.rucker@navy.mil](mailto:Linda.rucker@navy.mil)  
Dates of employment: Current employee, September 1987 – present

Ryan Sasse  
Realty Specialist  
Naval Facilities Engineering Command, Mid-Atlantic  
9742 Maryland Avenue  
Norfolk, VA 23511  
757-341-2004  
[Ryan.sasse@navy.mil](mailto:Ryan.sasse@navy.mil)  
Dates of employment: Current employee, April 2009 - present

Matthew Staden  
Navy Records Manager  
Office of the Chief of Naval Operations,  
Director of Navy Staff (Deputy DNS-5)  
720 Kennon Street, S.E., Bldg. 36  
Washington Navy Yard  
Washington, D.C. 20374

202-433-4217

[Matt.staden@navy.mil](mailto:Matt.staden@navy.mil)

Kenneth Williams

MSC Enterprise Records Manager

Military Sealift Command

914 Charles Morris Court, SE

Washington Navy yard, 20398-5540

202-685-5718

[Kenneth.j.williams1@navy.mil](mailto:Kenneth.j.williams1@navy.mil)

Dates of employment: Current employee, February 2004 - present

Dominick G. Yacano

Associate Counsel

Commander, Navy Region Mid-Atlantic

Office of Counsel

1510 Gilbert Street, Bldg. N-21

Norfolk, VA 23511

757-444-1395

[Dominick.yacono@navy.mil](mailto:Dominick.yacono@navy.mil)

Dates of employment: Current employee, September 2010 – present

Stephanie Zamorski

Real Estate Specialist

BRAC Program Management Office Northeast

4911 South Broad Street

Philadelphia, PA 19112

215-897-4905

[Stephanie.zamorski@navy.mil](mailto:Stephanie.zamorski@navy.mil)

Dates of employment: Current employee, November 1989 - present

#### **Sources Reviewed and Location:**

1) Naval Sea Systems Command, Washington Navy Yard, D.C.:

04XI databases (Installations and Equipment)

NAVAL SO database (Navy Asbestos related documents dating to 1880)

All Access Databases: RG181Shore, RG346NAVORD, RG313Operating Forces, RG19BUSHIPS (containing drawings, plans, files, contracts, etc. stored at Washington National Records Center)

2) Naval Facilities Engineering Command, Mid-Atlantic, Norfolk, VA:

Building LP-20 (Real Estate Records Archive)

3) BRAC Program Office, Philadelphia, PA:

Electronic and hardcopy records at BRAC Program Management Office

4) Commander Navy Region Mid-Atlantic, Norfolk, VA:

Internet search

5) Office of Naval Research, Arlington, VA:

ONR Contract Records and SF 135s (Records Transfer and Receipt). The ONR contracts department just located an additional file folder containing a list of ONR contracts dating back to approximately 1946. It is unclear whether the contract records associated with the list still exist. The list does not contain "accession numbers" needed for archival retrieval. However, some contracts on the list contain "job numbers" that can possibly be cross-referenced to identify a possible accession number. The records associated with the identified accession numbers would then have to be ordered from the Washington National records Center and reviewed. It is anticipated that this process may take a month or more and the response will be supplemented as soon as possible.

6) Washington National Records Center, Suitland, MD:

Search for items identified in ONR Search (Accession Number W298-0005411 under SF 135 dated 16 November 1950; Accession Number W298-0007718 under SF 135 dated 2 October 1952; Accession number W298-0010019 under SF 135 dated 14 June 1954). Multiple boxes requested from National Records Center were received by ONR during the week of January 23, 2012 and are in the process of review. Nine boxes have been reviewed and 38 remain for review. The majority of the boxes contain classified material and all boxes and documents are in a deteriorated state. Review and possible production of documents presents challenges. It is anticipated that the review of these boxes will be completed by February 1<sup>st</sup>. This response will be supplemented as soon as possible to address any responsive information found in these sources.

7) Naval Facilities Engineering Command, Atlantic, Norfolk, VA:

NAVFAC electronic files, index of maintained hardcopy files, NARA Online information for 3<sup>rd</sup> Naval District

8) Military Sealift Fleet Support Command, Norfolk, VA:

Hardcopy and electronic files at MSFSC offices in Norfolk

9) Military Sealift Command, Washington Navy Yard, D.C.:

Review of SF 135s (Records Transfer and Receipt)

CERTIFICATION OF ANSWERS TO REQUEST FOR INFORMATION  
NEWTOWN CREEK SUPERFUND SITE

State of Virginia:

County of Norfolk:

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document (response to EPA Request for Information) and all documents submitted herewith, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete, and that all documents submitted herewith are complete and authentic unless otherwise indicated. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. I am also aware that the Navy is under a continuing obligation to supplement its response to EPA's Request for Information if any additional information relevant to the matters addressed in EPA's Request for Information or my Navy's response thereto should become known or available to the Navy.

Robert G. Schirmer  
NAME (print or type)

ENVIRONMENTAL RESTORATION PLC  
TITLE (print or type)

NAVFAC MID-LANT  
NAVY NAME

Robert M. Schirmer  
SIGNATURE

Sworn to before me this 27<sup>th</sup> day of January 2012

Deborah Jeanne Abell  
Notary Public

My commission expires: 11/30/2013



THE SECRETARY OF THE NAVY

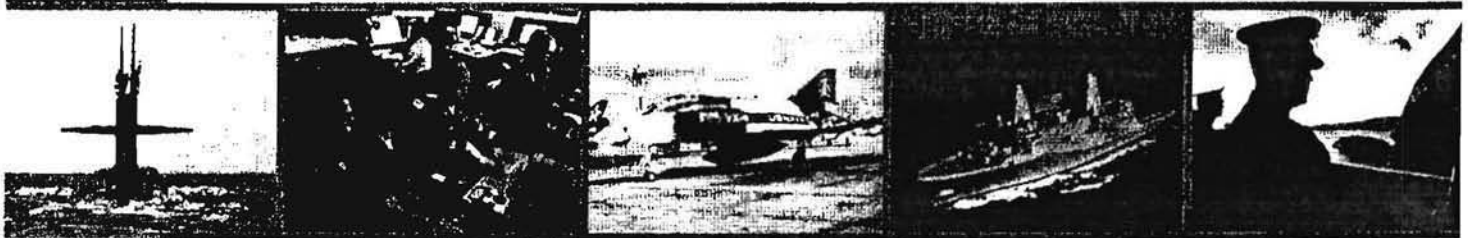


SECNAV M-5210.1  
NOVEMBER 2007 (REV.)

CHANGE (1) SEPTEMBER 2009 INCORPORATED

DEPARTMENT OF THE NAVY  
NAVY RECORDS MANAGEMENT PROGRAM

RECORDS MANAGEMENT MANUAL



PUBLISHED BY  
THE DEPARTMENT OF THE NAVY CHIEF INFORMATION OFFICER  
NOVEMBER 2007 REVISION  
CHANGE (1) SEPTEMBER 2009 INCORPORATED

Encl. 4

Destroy 2 years after approval or disapproval. (N1-NU-89-4)

b. Correspondence or Memoranda. Records pertaining to awards from other government agencies or private organizations.

Destroy when 2 years old. (N1-NU-89-4)

2. Length of Service and Sick Leave Awards File. Records including correspondence, memoranda, reports, computations of service and sick leave, and list of awardees.

Destroy when 1 year old. (N1-NU-89-4)

3. Letters of Commendation and Appreciation. Copies of letters recognizing length of service and retirement and letters of appreciation and commendation for performance. (Exclude copies filed in the Official Personnel Folder (OPF).)

Destroy when 2 years old. (N1-NU-89-4)

4. List or Indexes to Agency Award Nominations. List of nominees and winners and indexes of nominations.

Destroy when superseded or obsolete. (N1-NU-89-4)

5. Departmental Level Awards Files. Records relating to awards made at the departmental level or higher (Presidential, Secretarial, etc.).

PERMANENT. Transfer to FRC when 4 years old.  
Offer to NARA when 20 years old. (N1-NU-89-4)

SSIC 5062  
CHRISTENING CEREMONIES AND PROCEDURES  
RECORDS

Name and Sponsor Files. General Correspondence pertaining to Christening Ceremonies.

PERMANENT. Retire to WNRC when 4 years old.  
Transfer to NARA when 20 years old. (N1-NU-89-4)

SSIC 5070  
LIBRARIES AND LIBRARY SERVICES RECORDS

These Records are Accumulated by Librarians or Others Responsible for Maintaining Library Collections.

1. Library Catalog and Source Cards, List Books, Magazines, Reports, and Other Library Materials.

Destroy immediately after all copies of publications are withdrawn from the library collection. Transfer catalog cards for any material transferred to NARA with records. (N1-NU-89-4)

2. Shelf Lists. Records of all documents making up library

collections.

Destroy when library is disestablished. (N1-NU-89-4)

3. Chargeout Records. Chargeout cards or other records of material on loan, waiting lists, overdue notices, and other similar control records.

Destroy when document is returned or inventoried, after chargeout card is filled, or after appropriate action has been taken. (N1-NU-89-4)

4. Inter-Library Loan Logs or Other Similar Records.

Destroy when 4 years old. (N1-NU-89-4)

5. Technical Publications Library (TPL) Records. Files consist of publications designated as Code 4 publications in the Navy (forms and publications) supply system and other similar non-Communications Material System (CMS)-distributed publications and accumulated by commands and by other naval activities and offices.

a. Transaction Files. Copies of all correspondence pertaining to the handling of the TPL publications, including local memoranda, allowance lists, and change entry certification forms.

Destroy when 2 years old. (N1-NU-89-4)

b. Custody Record Files. Files of TPL catalog cards for each basic publication under control in the TPL.

Destroy 2 years after publication is transferred, lost or destroyed. (N1-NU-89-4)

c. Change Entry Certification Forms. Upper portion of form used as receipt for change. (See also SSIC 5070.5a.)

Destroy when date of change entry is made on TPL catalog card. (N1-NU-89-4)

d. Inventory Reports of TPL Material on board.

Destroy when 2 years old. (N1-NU-89-4)

SSIC 5080  
CIVIL AFFAIRS, MILITARY GOVERNMENT,  
RECORDS

1. The U.S. Army has Lead Responsibility for the DOD Civil Affairs and Military Government Program.

Apply Army Record Information Management System (ARIMS) (AR) 25-400-2 for descriptions of records and disposal authorities. (N1-NU-89-4)

SSIC 5090  
GENERAL ENVIRONMENTAL PROTECTION  
RECORDS

**1. Drinking Water Records.** Forms and correspondence documenting results of tests, analyses, and measurements.

**a. Bacteriological Results.**

Destroy when 5 years old. (N1-NU-89-4)

**b. Chemical/Physical Results.**

Destroy when 10 years old. (N1-NU-89-4)

**2. Hazardous Waste Records.**

**a. Manifests and Copies of Reports Submitted to Environmental Protection Agency (EPA).**

Destroy when 3 years old. (N1-NU-89-4)

**b. Test Results or Waste Analyses.**

Destroy 3 years after waste is sent to a Treatment Storage Disposal (TSD) facility. (N1-NU-89-4)

**c. Transporter Records.** Copies of manifests signed by the generator, transporter and TSD facility owner/operator.

Destroy 3 years from date of acceptance by original transporter. (N1-NU-89-4)

**d. Inspection and Maintenance Records of PCB Transformers or Electromagnets.**

Destroy 3 years after disposal of transformer/electromagnet. (N1-NU-89-4)

**e. PCB Inventory, Validation and Accountability Records.**

Destroy when 3 years old. (N1-NU-89-4)

**3. Hazardous Substance Records.** Includes reports and other records required by the Comprehensive Environmental Response Compensation Liability Act.

Retire to nearest FRC 3 years after completion of response action. Destroy when 50 years old. (N1-NU-89-4)

**a. Management Plans and support documentation.**

Destroy when superseded or obsolete whichever is later. (N1-NU-89-4)

**4. General Environmental Reports and Documentation Not Covered Elsewhere in this Manual.** Includes environmental assessments; environmental impact statements; life-cycle analyses; documentation of compliance/noncompliance; documentation required by the Army Corps of Engineers; site inspections;

communications with non-DOD Federal, State, Local and Foreign environmental authorities; and all other documentation required by law, regulation, and executive order, including reports to the EPA. Records include the affect of activities on air quality; tideland and fresh water wetland resources; wildlife; protected threatened, and endangered species; woodland resources; coastal and contiguous zone waters; noise levels; farm land; private property; land/property of historical/archeological value; and toxic waste sites. Note: current edition of OPNAV INSTRUCTION 5090.1 contains up-to-date lists of current laws, executive orders, regulations, and directives.

Retire to nearest FRC when 5 years old. Destroy when 30 years old. (N1-NU-89-4)

**5. Control of Lead and Copper.** Marine Corps owned and operated public water systems in the United States subject to the Lead and Copper Control requirements must retain original records of all sampling data and analysis, reports, surveys, letters, evaluations, schedules, state determinations, and any other information requires in 40 CFR 141.81 through 40 CFR 141.88.

(Note: Electronic version of records created by electronic mail and word processing application: Delete when file copy is generated or when no longer needed for reference or updating.)

Retire to FRC after 3 years and destroy after 12 years. (N1-NU-00-1)

**SSIC 5100**

**SAFETY AND OCCUPATIONAL HEALTH RECORDS**

The records described in this paragraph are accumulated throughout the DON by activities and offices concerned with safety matters for Military and Civilian Personnel. (See SSIC 6200.2.)

**1. General Correspondence Files of Activities and Offices and Other Organizational Units Concerned with Safety Matters relating to Civilian and Military Personnel.**

Destroy when 2 years old. (N1-NU-89-4)

**2. Safety Engineers Reports of Inspection and related Correspondence and Papers Reflecting Recommendations and Results.**

**a. Naval Activities.**

Destroy when 3 years old or upon discontinuance of facility, whichever is earlier. (N1-NU-89-4)

**b. Privately Owned Facilities Assigned Security Cognizance by DON.**

Destroy when 4 years old or security cognizance is terminated, whichever is earlier. (N1-NU-89-4)

## FEDERAL ACQUISITION REGULATION

### SUBPART 4.8 – GOVERNMENT CONTRACT FILES

#### 4.805 Storage, handling, and disposal of contract files.

(a) Agencies must prescribe procedures for the handling, storing, and disposing of contract files. These procedures must take into account documents held in all types of media, including microfilm and various electronic media. Agencies may change the original medium to facilitate storage as long as the requirements of Part 4, law, and other regulations are satisfied. The process used to create and store records must record and reproduce the original document, including signatures and other written and graphic images completely, accurately, and clearly. Data transfer, storage, and retrieval procedures must protect the original data from alteration. Unless law or other regulations require signed originals to be kept, they may be destroyed after the responsible agency official verifies that record copies on alternate media and copies reproduced from the record copy are accurate, complete, and clear representations of the originals. Agency procedures for contract file disposal must include provisions that the documents specified in paragraph (b) of this section may not be destroyed before the times indicated, and may be retained longer if the responsible agency official determines that the files have future value to the Government. When original documents have been converted to alternate media for storage, the requirements in paragraph (b) of this section also apply to the record copies in the alternate media.

(b) If administrative records are mixed with program records and cannot be economically segregated, the entire file should be kept for the period of time approved for the program records. Similarly, if documents described in the following table are part of a subject or case file that documents activities that are not described in the table, they should be treated in the same manner as the files of which they are a part. The retention periods for acquisitions at or below the simplified acquisition threshold also apply to acquisitions conducted prior to July 3, 1995, that used small purchase procedures. The retention periods for acquisitions above the simplified acquisition threshold also apply to acquisitions conducted prior to July 3, 1995, that used other than small purchase procedures.

Document	Retention Period
(1) Records pertaining to Contract Disputes Act actions.	6 years and 3 months after final action or decision for files created prior to October 1, 1979. 1 year after final action or decision for files created on or after October 1, 1979.
(2) Contracts (and related records or documents, including successful proposals) exceeding the simplified acquisition threshold for other than construction.	6 years and 3 months after final payment.

(3) Contracts (and related records or documents, including successful proposals) at or below the simplified acquisition threshold for other than construction.	3 years after final payment.
(4) Construction contracts:	
(i) Above \$2,000.	6 years and 3 months after final payment.
(ii) \$2,000 or less.	3 years after final payment.
(iii) Related records or documents, including successful proposals, except for contractor's payrolls (see (b)(4)(iv)).	Same as contract file.
(iv) Contractor's payrolls submitted in accordance with Department of Labor regulations, with related certifications, anti-kickback affidavits, and other related papers.	3 years after contract completion unless contract performance is the subject of an enforcement action on that date.
(5) Solicited and unsolicited unsuccessful offers, quotations, bids, and proposals:	
(i) Relating to contracts above the simplified acquisition threshold.	If filed separately from contract file, until contract is completed. Otherwise, the same as related contract file.
(ii) Relating to contracts at or below the simplified acquisition threshold.	1 year after date of award or until final payment, whichever is later.
(6) Files for canceled solicitations.	5 years after cancellation.
(7) Other copies of procurement file records used by component elements of a contracting office for administrative purposes.	Upon termination or completion.
(8) Documents pertaining generally to the contractor as described at <u>4.801(c)(3)</u> .	Until superseded or obsolete.
(9) Data submitted to the Federal Procurement Data System (FPDS). Electronic data file maintained by fiscal year, containing unclassified records of all procurements other than simplified acquisitions, and information	5 years after submittal to FPDS.

required under <u>4.603</u> .	
(10) Investigations, cases pending or in litigation (including protests), or similar matters.	Until final clearance or settlement, or, if related to a document identified in (b)(1) - (9), for the retention period specified for the related document, whichever is later.

# 400 TRUCKS RUSH NAVY OIL TO HOMES

585,000 Gallons of Emergency  
Fuel Delivered in Day—East  
Coast Exports Embargoed

By CHARLES GRUTZNER

Four hundred fuel trucks drained 585,000 gallons of Navy oil yesterday from seven storage terminals and delivered it to homes throughout the city on emergency authorization from the police, as the cold spell continued.

In one of the busiest days of the winter, the Mayor's Emergency Fuel Committee issued certificates to 439 dealers permitting oil withdrawals from the police-supervised pool. These withdrawals included 32,000 gallons of kerosene.

Six other terminals, designated to help dispense the Navy oil, had not received their share of the 2,730,000 gallons of Diesel oil lent for distribution in this city. They are expected to get it today.

An embargo on all fuel oil exports from East Coast ports was established yesterday by the De-

Continued on Page 3. Column 1

**The New York Times**

Published: February 10, 1948  
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Encl. 5 (includes CD)

# 585,000 Gallons of Emergency Navy Oil Delivered to City Homes in Day

NAVY-RELEASED OIL GOES FOR EMERGENCY USE HERE

Continued From Page 1

partment of Commerce to conserve dwindling supplies here.

It was announced in Albany meanwhile that the Office of Defense Transportation was ready to assign extra railroad tank cars to carry oil for the fuel-short state. The Associated Press said the Federal agency had asked Governor Dewey and Erastus Corning, Mayor of Albany, for specific information on where the fuel was available.

Governor Dewey had asked the ODT on Saturday to allocate at least 300 tank cars in the state to forestall "an emergency fuel oil situation," which, he said, could develop within two weeks. He urged that the cars be made available to the Navy and that the oil companies at their terminal facilities in New York harbor.

## Pool Also Gets Heavy Oil

The city's emergency fuel limited to fuel to be used in the oil for household heating, received yesterday 840,000 gallons of No. 6, the heavy oil used in large apartment buildings and industrial plants. The Navy and the State Oil Company as no-heat complaints from apartment dwellers continued to mount.

As the pinch of the oil shortage lightened on most of the country, the city's emergency fuel situation was not so dire. In Washington, A. Krug warned in a letter to the city that the situation might become even worse. It was announced here that the Todd Shipyard Corporation was hurriedly recalling its fleet of tankers as a reserve anchorage.

The tankers are to be ready by the end of this month. Most of them are T-2 vessels, with unit capacities of 11,000 tons. The Navy announced that three of these ships in the Todd yard in Brooklyn and eleven in Hoboken.

Eight tankers are being reconditioned in Seattle, seven in Los Angeles, and three at Charleston, N. C. and three at Charleston, S. C. A Todd official said this was the largest number of ships of this type to be overhauled in the company's yards at one time.

Most of the ships are being "reconditioned" to be ready for service. When the overhauling is finished, the vessels will be turned over to their owners and operators, including foreign as well as American interests.

## Barge Operator Suspends

The Reinauer Transportation Company, which operates a fleet of oil barges in New York Harbor, announced that it was suspending business because it was unable to reach agreement with a union whose members have been on strike since last November.

The company said that it had laid off 200 workers and that it was such time as the 104 strikers return to work.

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As the pinch of the oil shortage lightened on most of the country, the city's emergency fuel situation was not so dire.



A Brooklyn resident sitting here above.

The New York Times, the Sunday

also 1,376 no-heat complaints from tenants. Complaints of price-gouging by some oil companies have been learned that certain dealers in Nassau County are resorting to price gouging.

Sprague said after a meeting with the Board of Supervisors and Police Commissioner John M. Beck. He said that the board had learned that certain dealers in Nassau County are resorting to price gouging.

He said fourteen small dealers had reported they were being "squeezed out" by bigger companies that control the oil supply.

In Philadelphia, Brig. Gen. Brenton G. Wallace, Pennsylvania State Emergency Fuel Coordinator, charged that several dealers were charging 30 to 35 cents a gallon for fuel oil.

He said there was a big black market in fuel oil and threatened to punish gougers "the moment we have the proof." He said that the board would be taken against profiteers in the absence of legal price controls.

The New York police have admitted they were powerless to act against gougers who sold fuel oil at prices as high as 30 cents a gallon.

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# NAVY SEEKS MASPETH SITE

## Hawkes Tells of \$5,000,000 Plan to Buy Supply Annex

WASHINGTON, Dec. 24 (AP) — The office of Senator Albert W. Hawkes, Republican, of New Jersey, said today that he had been informed that the Navy proposed in its budget for next year to buy for \$5,000,000 a property now leased at Maspeth, L. I., as a supply annex for the Brooklyn Navy Yard.

An aide to Mr. Hawkes said the Navy was using the property as a storage depot at a yearly rental of \$163,000.

Two aluminum melting plants, erected during the war are on the site. A spokesman for the War Assets Administration said the Navy had been leasing the area since the war and would continue to do so until June, 1948. He said no negotiations were under way concerning sale to the Navy.

Mr. Hawkes' office said that 23.2 acres of the 180-acre property have buildings from which all machinery has been removed and that the property was assessed by the City of New York last year at \$6,600,000.

A spokesman for the Navy said the property now was owned by the Reconstruction Finance Corporation.

**The New York Times**

Published: December 25, 1947

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## United States Naval Administration in World War II

## Bureau of Ordnance

## Guns and Mounts

No. 75

## Small Arms

### Chapter II

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#### a. Definition and Procurement Summary

Small arms include guns of caliber .60 and smaller. The principal weapons in this category are Springfield, Garand, and Enfield Rifles, Colt Pistols, revolvers, sub-machine guns, automatic rifles, caliber .30 and caliber .50 machine guns.[1]

The field of small arms furnished an excellent example of procurement by one Service for both. Compared with the Army, Navy requirements were relatively small, and hence procurement of these weapons was centered in the Army. This policy made for interchangeability of material, and facilitated the solution of supply problems in that competition for available sources and facilities capable of producing this special material as eliminated, however, in cases involving non-common small arms, the Bureau of Ordnance initiated direct procurement and informed the

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Ordnance Department, War Department of such orders.[2]

During the course of the War Army procurement of major small arms for Navy use totaled:[3]

Caliber .30 MG M1919A4	65,272
Caliber .30 M2 Trips Mount	24,003
Caliber .45 Thompson Sub-Machine Gun	183,973
Caliber .30 Rifle M1903	330,582
Miscellaneous Rifles	
BAR M1918A2	41,808

Carbine, Caliber .30 M1	808,372
Target, Caliber .22	60,968
Automatic Pistols	
Caliber .45 Colt	441,998
Caliber .22 Colt Ace/Hi Standard	60,289
Caliber .38 Revolver	228,780
12 Gauge Shotgun, Riot Type	81,225
Bayonet M1	279,000

Navy procurement of non-common small arms, with the exception of caliber .50 mounts, did not bulk large and consisted in the main of direct purchase of certain types of caliber .30 machine gun mounts and caliber .38 Smith and Wesson revolvers.

The Marine Corps procured its enormous requirements for small arms directly from the Army.

b. Procedure for Small Arms Procurement.

The Planning Division of the Bureau was charged

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with the responsibility of presenting Navy small arms requirements to the Army Service Forces for acceptance. As a rule these requirements were estimated twelve months in advance. [4] Once received by the Army Service Forces, Navy needs were combined with those of the Army and other Service branches. The final production program, determined by ASF on the basis of these figures, was certified to the Industrial Division of the Office of the Chief of Ordnance, War Department, for the placing of contracts. Upon receipt of the notice that Navy requirements had been accepted by the ASF, the Bureau of Ordnance (Production Division) placed Navy orders with the Chief of Ordnance, War Department, for each item in the quantity included in the published and accepted requirements. This order made Navy funds available to the War Department. The War Department was then committed to make monthly deliveries in accordance with these orders and with the published and accepted Navy requirements. However, since the requirements were calculated, submitted, and accepted for delivery twelve months in advance, errors were

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inevitable, and requirements had to be revised periodically, usually every three months or even monthly on critical items. The enormous quantities needed, plus the constantly changing requirements, made it almost impossible to keep production abreast of demands. For this reason it was necessary to allocate the material to the Services on the basis of a ratio of total

requirements to total production.

The actual monthly deliveries of small arms were not Initiated by the War Department until after the monthly meeting of the Joint Allocation's Committee at which time the quantities actually available for delivery were determined. Upon the receipt of its allocation, the Bureau (Production Division) issued shipping instructions to the War Department. Theoretically the War Department was then obligated to make delivery in accordance with these instructions within forty-five days; that is, all material allocated for one month had to be delivered not later than the 15th of the following month. When the material was actually delivered it was turned over to the Maintenance Division for issue and distribution.

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Briefly summarized, responsibility for small arms procurement was as follows:

Planning Division

Calculated, revised and maintained a statement of requirements formulated twelve months in advance. Obtained monthly allocations for necessary items.

Production Division

Placed orders, and by revision, maintained quantity on order of each item in accordance with the latest revised requirements. Issued shipping instructions and expedited deliveries of all items. Kept records of actual deliveries and made the distribution of funds to the proper appropriation.

Maintenance Division

Handled the issue and distribution to activities within the Navy.

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c. Problems

The consensus in the Bureau was that on the whole the small arms procurement program functioned relatively smoothly. It was true that difficulties were encountered from time to time, but compared with the over-all accomplishment such difficulties did not bulk large. One of the most frequent irritations sprang from the fact that it was often necessary for the Navy to accept allocations less than the published and accepted requirements, particularly on such items as rifles, carbines, and caliber .45 pistols. In other cases the Army was slow in making deliveries and exceeded the forty-five day period allowed after allocations were determined. Spare parts, packaging, and small arms ammunition were also subjected to criticism.

### 1. Spare Parts

Initially, weapons were received from the Army along with what was known as concurrent and maintenance spare parts, the items and quantities of which varied from time to time.[5] In many instances, delivery of

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spare parts was not actually made at the time the weapons were shipped to the Navy. Under this system it was impossible for the Bureau to perform adequate follow-up on deliveries and to prevent the accumulation of surpluses. At the Navy's request the Army agreed to deliver the weapons minus the spare parts.

Under the new agreement spare parts were procured from the Army on the basis of actual Navy requirements based on allowance lists and requisitions. The Naval Supply Depots, Norfolk, Virginia, and Oakland, California, were given authority to procure spare parts direct from the Army to maintain established stock levels without further reference to the Bureau. Arrangements were made with the Marine Corps Liaison Officer at Rock Island Arsenal, the originating point for Army shipping orders, to follow up Navy orders. It would have been very advantageous to have had a Navy Liaison Officer at Rock Island since, as might be expected, Navy business was processed after that of the Marine Corps.

### 2. Supply and Repair

Experience demonstrated that handling of small arms as standard stock at Naval Activities was

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not satisfactory. The establishment of separate ordnance sections at the major supply depots at Norfolk and Oakland, with ordnance trained personnel in key positions, did much to improve the supply system.

Small Arms Repair Shops were also set up at the Naval Supply Depots, Norfolk and Oakland, as well as at the Navy Yard, New York (Maspeth Annex) and the Naval Supply Depot, Guam. These shops were equipped to complete major overhaul, inspection, and packaging."[6]

### 3. Caliber .38 Special Ammunition Assembled with (Unjacketed)

In the late summer of 1941, it was recognized that the Navy's stock of caliber .45 Colt Automatic Pistols together with expected deliveries would not be adequate to meet anticipated

requirements. Although the caliber .38 Special Smith and Wesson Revolver was not a standard issue for the Navy, it was necessary to procure this weapon in large numbers if requirements for side arms were to be met.

At the time of initial procurement, COMINCH

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(Readiness) authorized Issues of the weapons to activities of the Continental Naval Districts in order that caliber .45 Pistols assigned to those districts could be released and made available for issues to personnel proceeding to combat areas. After this replacement, additional requirements for caliber .45 Pistols for Naval Construction Battalions could not be met and consequently Cominch (Readiness) authorized the issue of caliber .38 Revolvers to the Chief Petty Officers of these battalions. Shortly thereafter, the Bureau of Ordnance, in compliance with a request from ComAirPac, authorized the issue of caliber .38 revolvers to aircraft crews under orders to proceed to overseas bases.

The only ammunition available for use in this revolver was assembled with unjacketed (lead) bullets. The Bureau, questioning the advisability of issuing this ammunition in view of the provisions of the Hague Convention communicated with Cominch concerning this problem. Cominch in turn requested VCNO to verify a report that British personnel captured by the Germans had been summarily shot because they had unjacketed (lead) ammunition in their possession.

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ALUSNA London reported that no confirmation could be given this report. However, due to the highly critical shortage of side arms, it was impractical to withdraw completely caliber .38 Special Revolvers and unjacketed ammunition pending production of caliber .38 Special ammunition assembled with Jacketed bullets.

In August 1943, a communication from Commander Fleet Air, South Pacific, reported that the 13th Air Force (Army) had ordered all caliber .38 Revolvers turned in pending receipt of steel Jacketed ammunition. It was also stated that Army sources in that area had received reports that captured allied personnel had probably been shot because they were equipped with unjacketed ammunition. In the same communication, Commander Fleet Air, South Pacific, recommended that similar orders be issued to Naval Forces, if applicable. The Bureau promptly prepared and distributed Circular Letter A103-43 dated September 27, 1943, specifically prohibiting the possession or use of caliber .38 Special unjacketed (lead) ammunition by Navy personnel assigned to duty beyond the continental limits of the United

States.

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It was not long afterward, however, that caliber .35 Special ammunition assembled with jacketed bullets was available in sufficient quantities for general issue.[7]

#### 4. Belted Ammunition

The requirements of both the Army and Navy for caliber .30 and caliber .50 ammunition for use in aircraft machine guns became so enormous during the summer of 1941 that the Army decided to belt the ammunition at the time of manufacture. The belted ammunition was packed in terne-plate lined containers, and later, in wax dipped cartons which were packed in wooden boxes.

The Army's decision to pre-belt resulted from Its desire to provide active areas with machine gun ammunition which would be ready for immediate use. The Army expected that the good condition of the ammunition would be protected by packing in sealed container; and the then popular ratios for belting the various calibers would remain in favor indefinitely and, further, that ammunition pre-belted in such ratios

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could be used effectively regardless of the nature of the various missions to be performed. However, experience proved these expectations were fully realized.

Early in 1943 the Army requested information as to whether the Navy's ammunition requirements for the calibers .30 and .50 machine guns should be factory belted. The practicability of adopting pre-belted ammunition for Navy use was considered by technical groups in the Bureau and the following advantages and disadvantages established:

##### Advantages

- (a) Ammunition is ready for Immediate use without the necessity for belting thus effecting a saving in time and effort.
- (b) If rounds are properly seated in links after handling and shipment and the belting ratios are considered effective for the mission to be performed, it is not necessary to open sealed containers and thereby expose the ammunition until it is actually required for loading in planes.

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### Disadvantages

(a) In many cases pre-belted ammunition, in ratios that were prescribed as much as one year previously, will not meet new requirements. It requires considerable more effort and time to remove rounds and re-belt than to belt ammunition in desired ratios from separately packed types.

(b) The ammunition often arrives in a badly corroded condition due to the exposure to atmosphere caused by piercing of terne-plate liners by projectiles, electrolysis set up by contact of steel links with brass cartridge cases, and the occasional use of unseasoned wood blocks for interior packing.

(c) When it is necessary to classify any lot of ammunition as Grade 3, (unserviceable), all other lots with which the defective lot is belted is affected.

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(d) Pre-belted ammunition involves special purpose ammunition. The greater the variety of special purpose ammunition the greater the total quantity of stock that must be kept on hand.

(e) The component of belted ammunition which is most subject to corrosion is the metallic link. If links are furnished separately they can be set aside readily without rendering ammunition unserviceable due to corroded links.

At a conference which was attended by representatives of COMINCH. (readiness), the Chief of Naval Operations, and the Planning and Maintenance Divisions of the Bureau, these advantages and disadvantages were weighed carefully and the decision made that factory-belted ammunition would not be procured by the Navy. It was decided that the Navy would procure the various types of aircraft machine gun ammunition unbelted, and that upon specific requests, combat-loaded movements only would be furnished whatever portion of their aircraft

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ammunition was required for immediate use. Accordingly, Bureau of Ordnance Circular Letter A9-44, dated February 15, 1944, was prepared and distributed to acquaint the Naval service with this policy. However, in October 1944, the Commander in Chief U. S. Fleet, made exception of this policy and directed that the Bureau of Ordnance supply pre-belted ammunition to AE's and AKE's for replenishment of Fast Carrier and Bombardment Groups,

and for Initial use in Combat-loaded movements. These requirements were so great that, in order to meet them, it became necessary for the Navy to obtain pre-belted ammunition directly from the Army.[8]

### 5. Packaging

Late in 1942 an ever increasing number of reports were received from Navy activities in advanced areas which indicated that small arms and metallic belt links were not adequately packed to withstand service conditions. The Bureau contacted the Ordnance Department, U. S. Army, early In 1943 to acquaint that department with the contents of these reports; to make known the Navy's packaging requirements; and to attempt to obtain ammunition and links packed to meet Navy

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requirements.

The Navy was unsuccessful in obtaining an early solution to this packing problem. Consequently in the fall of 1943, the Navy Department placed a development contract with the Coolerator Company of Duluth, Minnesota, for the design of an acceptable small arms ammunition shipping box.

The final design of this box embodied a metal container with clamp-down, self-sealing lid. A contract for the manufacture of 50,000 boxes was placed with the National Enameling and Stamping Company of Long Island, New York. Complete drawings and specifications of this box, officially designated the Small Arms Ammunition Box, Mark 1, Mod 0, were transmitted to the Ordnance Department, War Department, accompanied by a statement of Navy requirements and a request that immediate action be taken to establish production lines to meet these requirements. The Army set up the required facilities, and before the expiration of the program supplied the Navy with 1,200,000 of these boxes.[9]

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*Transcribed and formatted by Thomas Wildenberg, HyperWar Foundation*

# Aluminum Leases Ended To Create 'Competition'

## Government-Owned Plants Will Be Taken by RFC Nov. 1, Company Having Rejected Offer for Temporary Operation

Special to THE NEW YORK TIMES.

WASHINGTON, Sept. 7—In a competition in the aluminum industry designed to create "competition in the aluminum industry," the Reconstruction Finance Corporation has ended its lease agreement with the Aluminum Company of America in respect to Government-owned aluminum plants and related facilities. Termination of the agreement will become effective at midnight, Oct. 31.

Under the agreement, the RFC stated, Alcoa would have been in control of the plants until various dates in 1947 and throughout 1948, thereby creating a situation which would have made it impossible to make immediate arrangement for the sale or lease of the plants to others so long as the lease was in effect.

As a result, the agency said that the lease was being terminated "for the purpose of freeing the plants from the Alcoa agreement so that they could be disposed of in a manner which would create

The action was taken upon the recommendation of the Surplus Property Board, the RFC stated.

The agency disclosed that, in the notice of termination which had been sent to Alcoa, it had offered to make an arrangement allowing the company to continue operation of any or all of the plants for one year, beginning Sept. 1, upon the terms of the existing lease, subject to termination upon sixty days' notice.

Alcoa replied, in declining to accept the offer, that such a lease would be in fact a sixty-day lease "and would leave our company in such an impracticable operating position that we cannot enter into any such arrangement."

In its announcement of the cancellation of the aluminum lease the Federal agency said:

"The Reconstruction Finance Corporation announced today that it had terminated its lease agree-

Continued on Page 11, Column 4

# ALUMINUM LEASES ENDED BY RFC

Continued From Page 1

ment with the Aluminum Company of America, effective midnight, Oct. 31, 1945, with respect to the aluminum reduction plants and related facilities at Jones Mills, Ark.; Los Angeles, Calif.; Massena, N. Y.; Spokane, Wash.; Troutdale, Ore., and the Alumina plants at Hurricane Creek, Ark., and Baton Rouge, La.

"This action, it was stated, was taken on the recommendation of the Surplus Property Board. Under the lease, Alcoa would have been in control of the plants until various dates late in 1947 and throughout 1948. It would, therefore, have been impossible to make immediate arrangement for the sale or lease of the plants to others so long as the lease was in effect.

"The lease was terminated for the purpose of freeing the plants from the Alcoa agreement so that they could be disposed of in a manner which would create competition in the aluminum industry.

"The Government agencies concerned have taken this course as an effort to conform to the recent decision of the United States Circuit Court of Appeals for the second circuit and to provide additional sources of supply of this material so essential to the national security.

"RFC released the attached letter addressed to Arthur V. Davis, chairman of Alcoa, and which accompanied the notice of termination.

"The notice of termination sent to Alcoa offered to make an arrangement whereby Alcoa would be permitted to continue to operate any or all of the plants for one year, commencing Sept. 1, 1945, upon the terms and conditions of the existing lease, except that the arrangement could be terminate on sixty days' written notice to either party.

"This offer was made in the hope that in the interests of maintaining employment it would be possible to arrange for the operation of the plants by Alcoa on a temporary basis. Alcoa has informed representatives of the RFC that it is not interested in making an arrangement of any kind for the temporary operation of the plants."

Following is the text of a letter sent to the Aluminum Company of America by the RFC's general counsel, John D. Goodloe:

"August 30, 1945.

"Dear Mr. Davis:

"This is to confirm the following statements made orally today when I handed Mr. Arthur Hall, your Washington representative, an executed duplicate copy of the enclosed notice of termination of RFC's agreement of lease dated Aug. 19, 1941, with the Aluminum Company of America covering certain aluminum reduction plants and certain alumina plants:

"1. Because of the time element we are giving the notice of termination now for the purpose of protecting and preserving what we think are our legal rights under the contract.

"2. We are perfectly willing and indeed are anxious to discuss the matter with you and your attorneys and if possible to adjust the whole matter of an amicable basis.

"3. In the event we can arrive at a mutually satisfactory basis for adjusting the matter or should you convince us that we are wrong in our present position, we will withdraw the notice of termination.

"While I am certain that Mr. Hall will convey this information to you as requested, I am taking the liberty of confirming it to you directly because we do not want you to feel that today's notice of termination is being given in a spirit of antagonism."

In the company's statement that its wartime operation of all Government-owned aluminum smelting and alumina plants was ending Oct. 31, it was said that RFC had canceled leases previously on smelting plants at Massena, N. Y.; Burlington, N. J., and Riverbank, Calif.

Volume Production for War

The plants have a total annual capacity in excess of 1,250,000,000 pounds of aluminum and 2,500,000,000 pounds of alumina, which is refined bauxite from which aluminum is extracted. The company produced 4,000,000,000 pounds of aluminum for war from these smelting plants.

The company built the plants for the Government and operated them under wartime leases. Their cost was nearly \$250,000,000. According to Alcoa, the company built them without profit and furnished about \$50,000,000 in working capital for their operation in addition to furnishing about \$175,000,000 in

working capital for Government-owned fabricating plants.

The company's statement said the Government had received about \$30,000,000 from operations of the leased plants.

Alcoa in Anti-Trust Battle

The decision of the Reconstruction Finance Corporation to cancel its agreement with the Aluminum Company of America follows a long legal battle in which the Department of Justice has been seeking to dissolve the company and to rearrange its property because it was alleged to be a monopoly in violation of the anti-trust laws. In April, 1937, the Justice Department filed suit in Federal Court here against the company. In an oral opinion by Federal Judge Caffey in October, 1941, the decision was given in favor of the company. However, the case was appealed by the Government and on March 12, this year a special United States Circuit Court of Appeals reversed the decision.

The special court did not uphold the Government's contention that the dissolution of the company should be ordered but remanded the case to the District Court in New York to determine whether eventually some sort of dissolution would be proper.

The company, controlled by the Mellon interests of Pittsburgh, pioneered the development of the aluminum industry in the United States. From its start in 1888 it has dominated the industry, a position which attained through the acquisition of a patent covering the electrolytic process for the reduction of aluminum from bauxite. However, the basic patents expired in 1909 and 1912.

Alcoa is engaged in all phases of production from the mining of the bauxite ore to the manufacture of the finished fabricated products. Because of the increased demand for its products, particularly in the aircraft field, the company just prior to the entrance of the United States into the war completed a five-year expansion program at a total cost in excess of \$300,000,000, which more than doubled its productive capacity.

Reflecting the expansion program and the heavy demand for aluminum for war purposes, the net income of the company last year amounted to \$31,693,000 after charges and taxes, equal after preferred dividend payments, to \$5.45 a common share. This compared with \$40,255,000 in 1943. In the immediate prewar years, earnings were much smaller, amounting to \$15,563,000 in 1938, while in 1932 the company reported a deficit of \$2,172,000.

The balance sheet of Alcoa at the close of last year showed current assets of \$208,228,000 and total assets of \$474,185,000. At that time, the company had \$115,539,000 of long-term debt outstanding.

# NAVY NAMES YARDS FOR POST-WAR USE

## Tells Senate Committee It Asks Private Firms to Maintain Units for Emergencies

WASHINGTON, Sept. 24 (AP)—The Navy's Bureau of Ships disclosed to the House Naval Committee today plans to retain the following activities during the post-war years:

### Industrial Activities

Navy Yard, Portsmouth, N. H., with Sommersworth annex.  
Boston Navy Yard.  
South Boston naval drydocks.  
New London, Conn., submarine base.  
Brooklyn Navy Yard, with Bayonne, N. J., and Maspeth, L. I., annexes.  
Philadelphia Navy Yard.  
Repair facilities at Trinidad, B. W. I., at San Juan, P. R., and at Guantanamo Bay, Cuba.

### Shipyard Facilities

American Bridge Co., Ambridge, Pa.  
Bath Ironworks Corp., Bath, Me.  
Bethlehem Steel Company, East Boston, Hoboken and Quincy, Mass.  
Bethlehem-Hingham Shipyard, Inc., Hingham, Mass.  
Cramp Shipbuilding Company, Philadelphia.  
Dravo Corporation, Neville Island, Pa. and Wilmington, Del.  
Electric Boat Company (Victory yard), Groton, Conn., and Electric Boat Corporation, Groton.  
Federal Shipbuilding and Drydock Company, Newark, and Kearny, N. J.  
New York Shipbuilding Corporation, Camden.  
Todd Shipyards, Brooklyn division, and Hoboken.

### General Industry Facilities

Air Reduction Sales Co., Hingham, Mass.  
Birdsboro (Pa.) Steel Foundry and Machine Co.  
Eric (Pa.) Forge and Steel Company.  
General Electric Company, Erie.  
Heppenstall-Eddystone Corp., Eddystone, Pa.  
Mesta Machine Company, West Homestead, Pa.  
Lukens Steel Company, Coatesville, Pa.  
Rustless Iron and Steel Company, Baltimore.

[The Navy indicated that its plan is to persuade the private companies to keep these plants in full operation so that they could be converted to Navy use on short notice. If this is not possible, the Navy said, the plants probably would be declared surplus.]

### Laboratories

Naval Boiler and Turbine Laboratory, Navy Yard, Philadelphia.  
Material Laboratory, Navy Yard, Brooklyn, N.Y.  
Test station, Ft. Miles, Lewes, Del.  
United States Navy metals laboratory, Munhall, Pa.  
Industrial test laboratory, Philadelphia.  
Material laboratory, Navy Yard, Boston.  
United States Navy underwater sound, Ft. Trumbull, New London.  
United States Navy Radio, radio and sonar laboratories at Boston, New York, Philadelphia, San Juan, P. R., and Balboa, C. Z.

### Reserve Fleet Berthing Sites

Submarine base, New London.  
Reserve basin, Navy Yard, Philadelphia; supply depot, Bayonne.  
Navy Yard annex, South Boston.

**The New York Times**

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	M-1937		Bi-Weekly Report, March 27, 1953	Laboratory Staff	U	
	M-1953		Bi-Weekly Report, April 10, 1953	Laboratory Staff	U	
	M-1997		Bi-Weekly Report, April 24, 1953	Laboratory Staff	U	
	M-2155		Bi-Weekly Report, May 8, 1953	Laboratory Staff	U	
REPORTS AND CORRESPONDENCE	R-71	7 Aug 45	DC Voltage Regulator	B. B. Drisko	U	
	R-68	1 Oct 45	Transformer Field Tests - Investigation of the Strength of the Magnetic Field Produced by Transformers Under Simulated Conditions of Normal Operation	M. Florencourt	U	
	Letter	19 Oct 45	To Ordnance Officer-in-Charge, Maspeth Annex, Navy Yard, New York - re: Request for Equipment in Connection with Contract NOa(s)7082	J. W. Forrester	U	
	C-1	22 Oct 45	ASCA Conference I - Accuracy of Wind Tunnel Data and Sensitivity of Solution Wednesday - October 24, 1945 9:00 - 10:30 A. M.	S. H. Dodd L. Bernbaum	U	
	E-1	23 Oct 45	Development Schedules	J. W. Forrester	U	

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2	Initialing of Approved Invoices	3-9-46	J. W. Forrester	U
3	Availability of Surplus Material at the Maspeth Annex	3-15-46	H. B. Morley	U
4	James Swett	3-18-46	J. W. Forrester	U
5	Interim Report on Scope Recorder	3-20-46	B. B. Driske	U
6	Simplified Equations of Motion: Model A Airplane	4-4-46	H. Fahnestock	U
7	Power Supplies	4-8-46	H. R. Boyd	U
8	Gaussian (Addition and Sub- traction) Logarithms	3-26-46	K. B. Tuttle	U
9	Conference with RCA Vacuum Tube Representatives, Messrs. J. H. Halgren, J. T. Wilson, and J. P. Driver on 3-3-46	4-24-46	J. W. Forrester	U
10	The ENIAC at University of Pennsylvania	4-29-46	J. W. Forrester	U
11	Approximation of Empirical Functions (Preliminary Inves- tigation)	4-24-46	K. B. Tuttle	U
12	Clarification of Some Points on Digital Computation	5-1-46	P. D. Tilton	U
13	Block Schematic Group	5-6-46	P. D. Tilton	U
14	Block Schematics	5-10-46	P. D. Tilton	U
15	S. D. Rich Submarine Signal	5-21-46	J. W. Forrester	U

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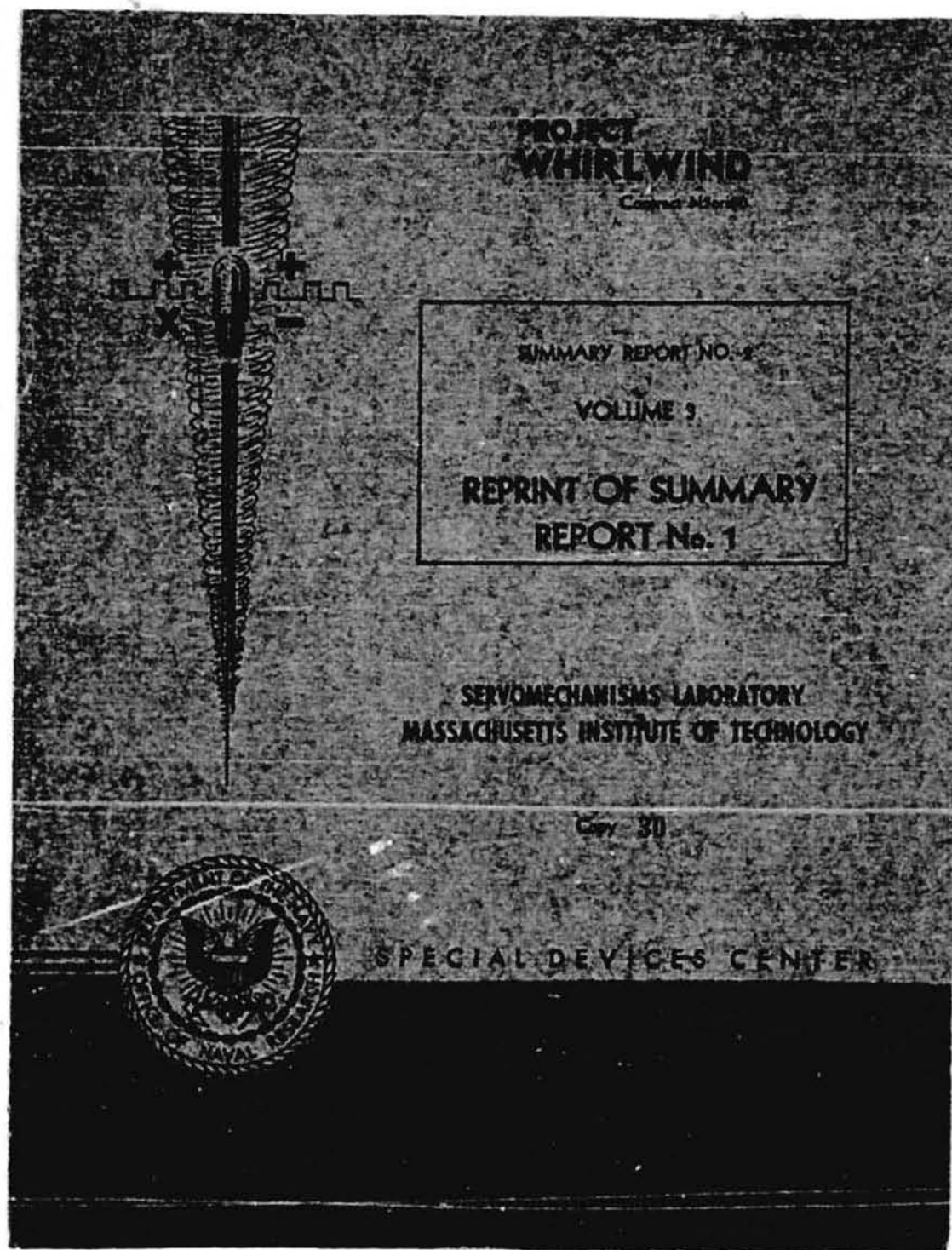
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**PROJECT  
WHIRLWIND  
(DEVICE RF-12)**

**SUMMARY REPORT NO. 1  
April 1946**

For the

**SPECIAL DEVICES DIVISION  
OFFICE OF RESEARCH AND INVENTIONS  
NAVY DEPARTMENT**

Issued Under the Provisions of  
Letter of Intent for Contract NOa(s)7082

By the

**SERVOMECHANISMS LABORATORY  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
Cambridge, Massachusetts**

**Research on Project WHIRLWIND  
Includes Contributions by the  
Department of Aeronautical Engineering  
Department of Electrical Engineering  
Department of Mathematics  
Department of Physics**

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FORWARD

Project WHIRLWIND reports will be issued monthly or bi-monthly from the Servomechanisms Laboratory at the Massachusetts Institute of Technology as available material justifies. They are prepared for the distribution, to authorized persons, of information on high-speed digital computation.

In some cases ideas will be suggested and circuits proposed which have not been proven in practice. As tests are made, results will be recorded in later issues of the WHIRLWIND.

The most rapid and efficient progress in new aids to mathematical computation can be achieved only through cooperation and interchange of information between scientific groups engaged in this field. Comments on the ideas presented in these reports are requested from other groups as well as information on results of work at other laboratories. Suitable letters and papers concerning digital computation will, with permission of the author, be included from time to time. Where information from sources outside this laboratory is of a non-classified nature, the publication will, at the request of the author, so indicate.

Correspondence can be addressed to Project WHIRLWIND, Servomechanisms Laboratory, Building 32, Massachusetts Institute of Technology, Cambridge, Massachusetts.

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REVIEW

Project WHIRLWIND, sponsored at the Massachusetts Institute of Technology by the Special Devices Division of the Office of Research and Inventions, U. S. Navy, is a program of research, investigation, and development in the field of high-speed electronic digital computation. As outlined in Summary Report No. 1, this electronic computer is specifically aimed at the solution of aircraft stability and control problems but will also provide for the solution of certain other classes of scientific problems as well as the field of non-linear ordinary differential equations. Completion of a final computer will require several years. Summary reports will be issued from time to time indicating the latest results and trends.

When the project was organized in December 1944 plans were based on the use of analogue computation. It became apparent that analogue methods would lead to excessive complexity and that other computing techniques should be studied. High-speed electronic digital computation is now being investigated in an effort to develop components for application to the problems of immediate interest.

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SUMMARY REPORT ON CONTRACTS NO<sub>N</sub>(s)6216 AND NO<sub>N</sub>(s)7082

PART A - INTRODUCTION

1. SUMMARY

In December, 1944, the Massachusetts Institute of Technology, Division of Industrial Cooperation, undertook to develop for the Navy a generalized multi-engine flight trainer. This was an outgrowth of work during the war by the Special Devices Division of the Bureau of Aeronautics which was later transferred to the Office of Research and Inventions.

Several flight trainers had been designed for Navy aircraft. These included the PBM, the PGP, and the PMY2. The trainers had proven so valuable and the representation of flying conditions so satisfactory that an extension into the generalized field of aircraft simulation appeared possible. The proposed research and development at M.I.T. had two broad objectives. One was the design of equipment for generalized training purposes and the second that this flight trainer equipment should be sufficiently accurate to serve as an aircraft stability and control computer.

As a stability and control analyzer the equipment would be set up in accordance with information obtained from wind tunnel model tests of a proposed aircraft design to solve the equations of motion for the aircraft as a rigid body in space and to compute sufficient of the aerodynamic forces to predict the flying quality of the tentative design.

An aircraft cockpit complete in detail would permit a test pilot to evaluate aircraft performance, and flight instruments would respond as expected for the new aircraft design. Control forces would be computed and applied to the cockpit controls and proper sound and vibration incorporated.

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The results would be obtained not only as impressions and opinions of the test pilot but also as completely recorded data showing motion of cockpit controls and resulting response of the aircraft. To accomplish this, some 30 or more variables would be recorded.

Since human pilot reactions do determine in part the aircraft flight behavior, this analyzer has the advantage of including an actual pilot rather than synthesizing his reactions. Because human response is a factor in the problem, indicated aircraft response must occur in real time. To compute aircraft motion on a one-to-one time scale will require much higher solution rates than have before been required of mathematical computation devices. This and other problems made a survey period necessary before the start of actual computer design.

Contract NO(s)5216 was set up to permit a study of the proposed aircraft analyzer and to study the feasibility of designing such a device. Certain obvious problems which had given trouble in the aircraft trainers were solved during the earlier phases of this contract. One such was the control force loading equipment to provide proper feel for the cockpit controls.

The heart of a device such as the aircraft analyzer is, of course, the computer, which solves equations of motion in response to actions of the pilot. The usual approach to such a computer was through use of analogue computing techniques, such as have been used in differential analyzers and fire control equipment. During the first ten months of activity on this project, various analogue computing techniques were studied. These were primarily components which could be used in an analogue computing system that represented mathematical quantities by magnitudes of alternating current voltages.

As work progressed, it became apparent that an analogue-type computer for the equations of aircraft motion would be so complicated that its accuracy and performance could not be predicted. Such a computer would also lack the flexibility and ease of setup that is desirable for the aircraft analyzer problem. Although several new computer

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techniques including a high-performance servo system were developed, it seemed better that other approaches to the analyzer problem be studied.

Because the amount of computation required for the aircraft analyzer problem appears greater than that practical for analogue computers, it is desirable to consider carefully the use of high-speed electronic digital computing methods.

During the organization of Contract W0a(s)7082, consideration was given digital methods of computation in the fall of 1945, and since that time a program has been initiated to adapt high-speed electronic computing methods to the aircraft analyzer problem. A computer which will solve the aircraft stability equations will have the required capacity for many other families of scientific problems. Consequently, effort at the present time is being devoted to the study and development of general electronic digital computing techniques. Approximately a year and a half will be devoted to studying and developing these methods, by which time their adaptability to the aircraft analyzer problem can be determined.

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- 4 -

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trainers was an expensive and time-consuming undertaking and the Special Devices Division undertook to develop a universal trainer into which constants for various types of aircraft could be set.

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Such a universal flight trainer was visualized as a computer with adjustable coefficients for the equations of aircraft motion. Constants for the aircraft could then be set into the equations and the computer would provide proper flight instrument data for any type of aircraft. Simultaneously with this concept of a universal flight trainer there developed a plan for using the equipment as an aircraft analyzer.

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In order that the equipment may function as an aircraft analyzer, it must predict rather than duplicate aircraft performance. In trainers, it has been the practice to adjust circuits which, in themselves, may not represent true mathematical equations, until proper behavior is achieved. An analyzer, on the other hand must take aerodynamic coefficients obtained from wind tunnel tests and use these to predict aircraft performance. The correct equations of motion must, therefore, be solved with sufficient sensitivity and accuracy to permit studies of aircraft stability and control.

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As a stability and control analyzer, the equipment would consist of a computer, a control room and auxiliary equipment, and a cockpit arranged to represent the proposed aircraft. An aircraft analyzer of the type visualized should perform three main functions.

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A considerable amount of the flight testing in the study of aerodynamic properties and control stability can be made with an analyzer of this type based upon information obtained from wind tunnel model studies. Such studies, to be sure, must be considerably

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An aircraft stability and control analyzer would permit the study of the more radical aircraft designs which, although perhaps entirely sound, might not be built for full-scale testing without some preliminary assurance of success.

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2.34 Analysis and Synthesis

Not only would an aircraft analyzer permit analysis of an aircraft from model studies but, by a reverse process, coefficients

- 6 -

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could be changed to obtain desirable performance and the aerodynamic properties of the model redesigned to produce these coefficients.

2.35 Aircraft Criteria

The availability of an aircraft analyzer would permit more complete investigations into the characteristics of successful aircraft. With aerodynamic characteristics under control and subject to rapid change, a better appreciation of factors affecting good aircraft performance could be achieved.

2.36 Study of Automatically Controlled Flight

In addition to the study of piloted aircraft such equipment should permit studies of aircraft under the control of automatic pilots as well as studies of guided missiles.

2.4 Flexibility

An analyzer which will solve the problems outlined above will be a computer of considerably greater complexity than any now existing. At first a permanent arrangement of computing elements was contemplated in the manner originally used in the operational flight trainers. It early became apparent that such a fixed schematic would be entirely impractical because the equations to be solved were undergoing continual change and because a computer of this size and potential usefulness should not be committed to a single type of problem. Plans therefore call for as much flexibility as possible in the type of problem to be solved by the computer portion of the aircraft analyzer.

3. PRESENT STATUS

3.1 Analogue Computing Summary

The first plan for the computer to solve aircraft stability equations followed the approach previously worked out for fire control computers and differential analyzers. In analogue computation a separate computing element is required for each mathematical step involved in the problem solution. The requirement of a real time

## Vessels

neg(R) 31361

## BETWEEN

AND


ay of December, 1942

x

**QWERTY**

1. The Permittee is not to be considered as acquiring any permanent interest of whatever nature in the property of the Permitter.
2. The charge of \$5.00 per boat shall be with the understanding that each boat will not be in the slip for more than twenty-four hours.
3. This permit shall not be assignable or transferable by the Permittee. The Permitter by the granting of this permit shall not be responsible for damage to any naval boats while in the aforesaid basin and shall not be liable for injury to any person or persons on board said boats or serving in connection therewith, and in the event that death or injury occurs to any person, or loss, destruction or damage occurs to any property in connection with the use of said basin by the Permittee occasioned by the acts or omissions of the Permittee's agents, employees or servants, the Permittee, out of funds as may be available therefor or which have been appropriated for this purpose by the Congress of the United States, agrees to indemnify and save harmless the Permitter from and against any loss, expense, claims and demands to which the Permitter may be subjected as the result of such death, loss, destruction, or damage.
4. No member of or delegate to Congress or resident commissioner shall be admitted to any share or part of this permit, or to any benefit to arise therefrom. Nothing, however, herein contained shall be construed to extend to any incorporated company, if the permit be for the general benefit of such corporation or company.

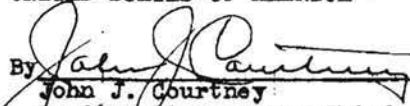
IN WITNESS WHEREOF, I have hereunto set my hand and affixed my seal the day and year first above written.

  
Henry C. Bohack, President  
Bohack Realty Corporation

THIS PERMIT is also executed by the Permittee in acknowledgment and acceptance of the terms herein set forth.

Payment to be made  
by Disbursement  
Officer, 3rd Naval  
District

UNITED STATES OF AMERICA

By   
John J. Courtney  
By direction of the Chief  
of the Bureau of Yards and  
Docks, Acting under direc-  
tion of the Secretary of  
the Navy

NO. 46:119

THIS AGREEMENT, made and entered into this 7th day of Sept. 1945, by and between THE LONG ISLAND RAIL ROAD COMPANY (hereinafter referred to as the "Company"), and UNITED STATES OF AMERICA represented by the Chief of the Bureau of Yards and Docks, acting under the direction of the Secretary of the Navy (hereinafter referred to as the "Industry");

WHEREAS, the Industry desires the use of two existing sidetracks and switch connections connecting with the Montauk Branch of the Company at points 2.54 and 2.55 miles east of Long Island City in the County of Queens, State of New York, as shown upon the blueprint of plan No. D. E. 1783, Revised date May 28, 1945, marked Exhibit "A", attached hereto and made a part hereof, and

WHEREAS, the Industry requests that the Company operate said tracks and switch connections shown on said blueprint for the purpose of serving the business carried on by the Industry, and

WHEREAS, the Company is willing to operate its engines, trains and cars upon, over and along said tracks, but only for the consideration, and on the terms and conditions hereinafter set forth:

NOW, THEREFORE, it is agreed by and between the parties hereto as follows:

912534  
1. OWNERSHIP. It is understood and agreed that the ownership of that part of said sidetrack indicated by yellow coloring on Exhibit "A" and all appurtenances thereunto belonging, shall be and the same is hereby vested in the Industry insofar as the parties hereto are concerned.

2. MAINTENANCE. The Industry will, at its sole cost and expense, out of available funds appropriated therefor, furnish the labor and materials necessary for, and maintain and renew in such safe operating condition as the Company shall deem proper during the continuance hereof, that part of said track indicated by yellow lines on Exhibit "A".

825205  
The ownership of materials used in renewing or maintaining said track or tracks shall be vested as provided by paragraph "1" hereof.

3. The Industry agrees to exercise the greatest care both in the use of said sidetracks and switch connections and to prevent cars which have been placed thereon for its use or benefit from getting out upon or too close to the main tracks of the Railroad Company, and the Industry agrees to keep said sidetracks and switch connections clear of snow, ice and other obstructions, and not to erect or allow to be erected any buildings, structure or fixture of any kind nearer than 8 feet from the center thereof measured laterally therefrom and nearer than 21 feet above top of rail measured vertically therefrom, except platforms which shall not be less than 6 feet 6 inches from said center of track or more than 3 feet 10 inches above said top of rail, unless such distances are otherwise indicated upon the blueprint attached hereto, which shall then govern.

4. This contract shall be binding upon and inure to the benefit of the successors and assigns of the parties hereto; provided, however, the Industry shall not assign this contract without the written consent of the Company.

5. No member or delegate to the Congress of the United States of America shall be admitted to any share or part of such agreement or to any benefit arising therefrom.

6. The cost and expense of procuring or complying with any ordinance, order, permit or consent whatsoever required by Municipal, State or other lawfully constituted authorities for the maintenance, operation and use of said sidetracks and switch connections shall be borne by the Industry.

7. The Company shall have the right to use the whole or any part of said sidetracks, provided such use shall not unreasonably interfere with the use thereof by the Industry.

8. If any change, rearrangement, extension or enlargement of said sidetracks or their structures shall at any time be necessary by reason of any change in the operation of the railroad, the Company shall not be required to bear any expense resulting therefrom.

THIS CONTRACT shall take effect on the date hereof, and unless sooner terminated as herein provided, shall continue in effect for the period of one year and thereafter subject to termination sixty (60) days after either party hereto shall have given to the other notice in writing of its intention to terminate the same.

IN WITNESS WHEREOF, the parties hereto have caused this contract to be executed, as of the day and year first above written.

THE LONG ISLAND RAIL ROAD COMPANY

By

E. J. Sheehan  
Superintendent

WITNESS:

J. J. Sheehan

THE UNITED STATES OF AMERICA

By

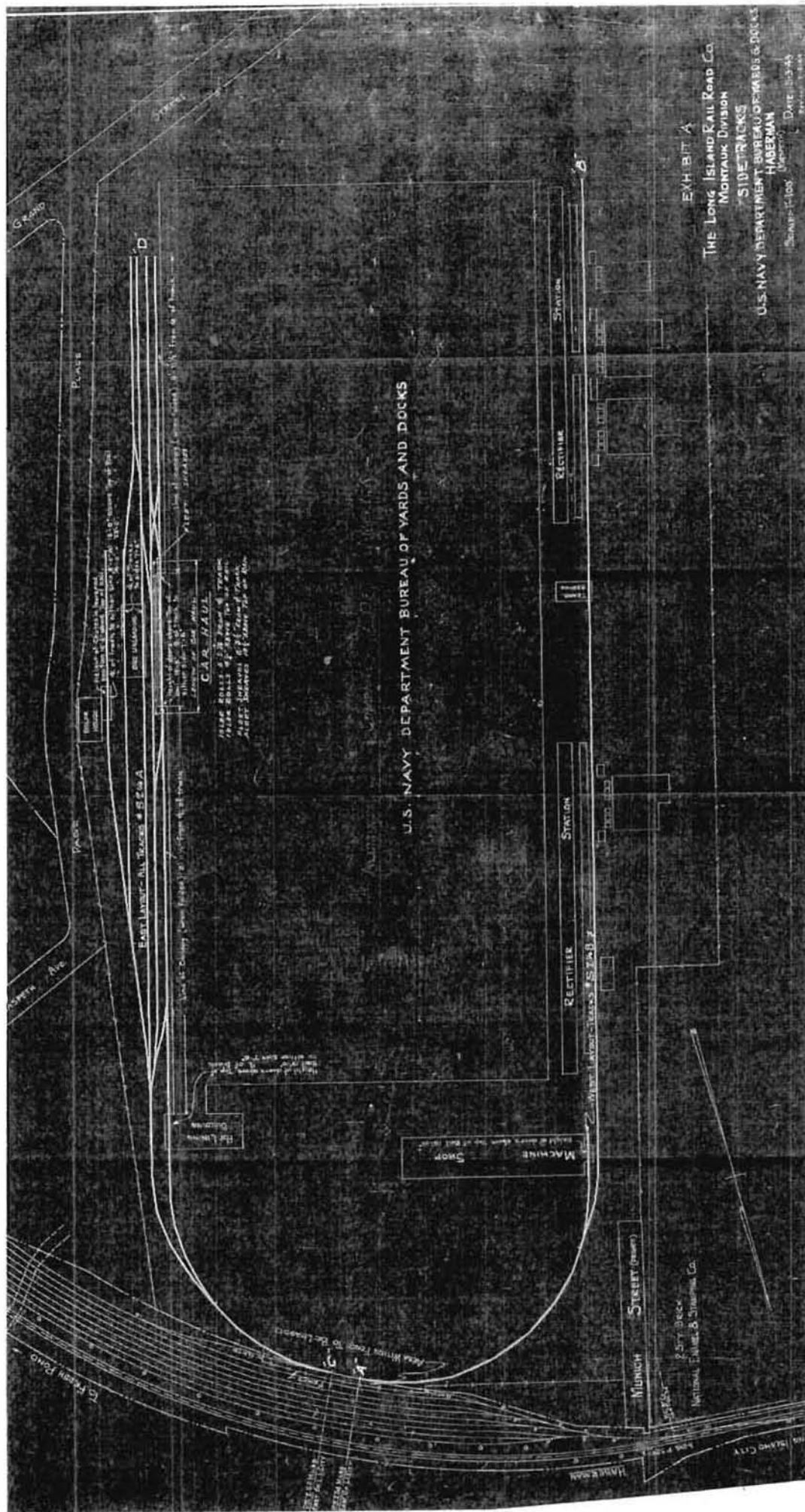
Andrew J. Murphy, Jr.

Andrew J. Murphy, Jr.  
By direction of the Chief of  
the Bureau of Yards and Docks,  
acting under the direction of  
the Secretary of the Navy

WITNESS:

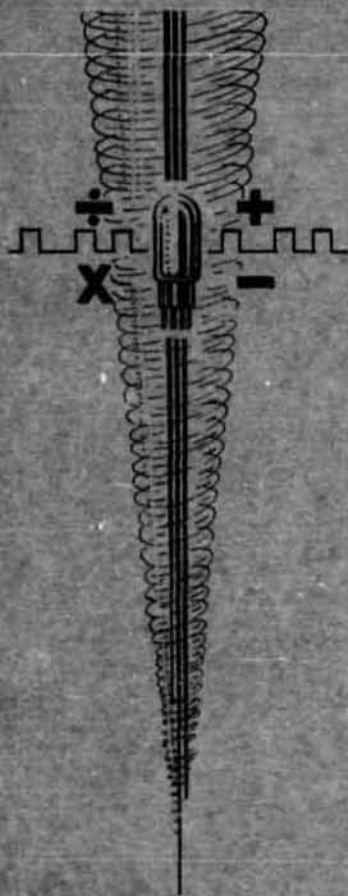
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FORM APPROVED <sup>ask.</sup>  
Lawrence  
GENERAL ATTORNEY  
THE LONG ISLAND  
RAIL ROAD COMPANY  
7-27-44



U.S. NAVY DEPARTMENT BUREAU OF YARDS AND DOCKS

EXHIBIT A  
 THE LONG ISLAND RAIL ROAD CO.  
 MONTAUK DIVISION  
 SIDETRACKS  
 U.S. NAVY DEPARTMENT BUREAU OF YARDS AND DOCKS  
 HABERMAN  
 SCALE: 1" = 100' Date: 1914



# PROJECT WHIRLWIND

Contract N5ori60

SUMMARY REPORT NO. 2

VOLUME 3

REPRINT OF SUMMARY  
REPORT No. 1

SERVOMECHANISMS LABORATORY  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Copy 30



SPECIAL DEVICES CENTER

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**PROJECT  
WHIRLWIND  
(DEVICE RF-12)**

**SUMMARY REPORT NO. 1  
April 1946**

**For the**

**SPECIAL DEVICES DIVISION  
OFFICE OF RESEARCH AND INVENTIONS  
NAVY DEPARTMENT**

**Issued Under the Provisions of  
Letter of Intent for Contract NOa(s)7082**

**By the**

**SERVOMECHANISMS LABORATORY  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
Cambridge, Massachusetts**

**Research on Project WHIRLWIND  
Includes Contributions by the  
Department of Aeronautical Engineering  
Department of Electrical Engineering  
Department of Mathematics  
Department of Physics**

This document contains information affecting the national defense of the United States under the Rulings of the Espionage Act 50, U. S. C., 31 and 32, as amended. Its transmission or the revelation of its contents in any instance to an unauthorized person is prohibited by law.

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FORWARD

Project WHIRLWIND reports will be issued monthly or bi-monthly from the Servomechanisms Laboratory at the Massachusetts Institute of Technology as available material justifies. They are prepared for the distribution, to authorized persons, of information on high-speed digital computation.

In some cases ideas will be suggested and circuits proposed which have not been proven in practice. As tests are made, results will be recorded in later issues of the WHIRLWIND.

The most rapid and efficient progress in new aids to mathematical computation can be achieved only through cooperation and interchange of information between scientific groups engaged in this field. Comments on the ideas presented in these reports are requested from other groups as well as information on results of work at other laboratories. Suitable letters and papers concerning digital computation will, with permission of the author, be included from time to time. Where information from sources outside this laboratory is of a non-classified nature, the publication will, at the request of the author, so indicate.

Correspondence can be addressed to Project WHIRLWIND, Servomechanisms Laboratory, Building 32, Massachusetts Institute of Technology, Cambridge, Massachusetts.

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## REVIEW

Project WHIRLWIND, sponsored at the Massachusetts Institute of Technology by the Special Devices Division of the Office of Research and Inventions, U. S. Navy, is a program of research, investigation, and development in the field of high-speed electronic digital computation. As outlined in Summary Report No. 1, this electronic computer is specifically aimed at the solution of aircraft stability and control problems but will also provide for the solution of certain other classes of scientific problems as well as the field of non-linear ordinary differential equations. Completion of a final computer will require several years. Summary reports will be issued from time to time indicating the latest results and trends.

When the project was organized in December 1944 plans were based on the use of analogue computation. It became apparent that analogue methods would lead to excessive complexity and that other computing techniques should be studied. High-speed electronic digital computation is now being investigated in an effort to develop components for application to the problems of immediate interest.

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R 30011	A 38005-G
D 30012	B 38008-G
D 30013	A 38045-G
C 30063	A 38053-G

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## SUMMARY REPORT ON CONTRACTS NOa(s)5216 AND NOa(s)7082

PART A - INTRODUCTION

## 1. SUMMARY

In December, 1944, the Massachusetts Institute of Technology, Division of Industrial Cooperation, undertook to develop for the Navy a generalized multi-engine flight trainer. This was an outgrowth of work during the war by the Special Devices Division of the Bureau of Aeronautics which was later transferred to the Office of Research and Inventions.

Several flight trainers had been designed for Navy aircraft. These included the PBM, the F6F, and the PB4Y2. The trainers had proven so valuable and the representation of flying conditions so satisfactory that an extension into the generalized field of aircraft simulation appeared possible. The proposed research and development at M.I.T. had two broad objectives. One was the design of equipment for generalized training purposes and the second that this flight trainer equipment should be sufficiently accurate to serve as an aircraft stability and control computer.

As a stability and control analyzer the equipment would be set up in accordance with information obtained from wind tunnel model tests of a proposed aircraft design to solve the equations of motion for the aircraft as a rigid body in space and to compute sufficient of the aerodynamic forces to predict the flying quality of the tentative design.

An aircraft cockpit complete in detail would permit a test pilot to evaluate aircraft performance, and flight instruments would respond as expected for the new aircraft design. Control forces would be computed and applied to the cockpit controls and proper sound and vibration incorporated.

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The results would be obtained not only as impressions and opinions of the test pilot but also as completely recorded data showing motion of cockpit controls and resulting response of the aircraft. To accomplish this, some 30 or more variables would be recorded.

Since human pilot reactions do determine in part the aircraft flight behavior, this analyzer has the advantage of including an actual pilot rather than synthesizing his reactions. Because human response is a factor in the problem, indicated aircraft response must occur in real time. To compute aircraft motion on a one-to-one time scale will require much higher solution rates than have before been required of mathematical computation devices. This and other problems made a survey period necessary before the start of actual computer design.

Contract NOn(s)5216 was set up to permit a study of the proposed aircraft analyzer and to study the feasibility of designing such a device. Certain obvious problems which had given trouble in the aircraft trainers were solved during the earlier phases of this contract. One such was the control force loading equipment to provide proper feel for the cockpit controls.

The heart of a device such as the aircraft analyzer is, of course, the computer, which solves equations of motion in response to actions of the pilot. The usual approach to such a computer was through use of analogue computing techniques, such as have been used in differential analyzers and fire control equipment. During the first ten months of activity on this project, various analogue computing techniques were studied. These were primarily components which could be used in an analogue computing system that represented mathematical quantities by magnitudes of alternating current voltages.

As work progressed, it became apparent that an analogue-type computer for the equations of aircraft motion would be so complicated that its accuracy and performance could not be predicted. Such a computer would also lack the flexibility and ease of setup that is desirable for the aircraft analyzer problem. Although several new computer

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Because the amount of computation required for the aircraft analyzer problem appears greater than that practical for analogue computers, it is desirable to consider carefully the use of high-speed electronic digital computing methods.

During the organization of Contract NOn(s)7082, consideration was given digital methods of computation in the fall of 1945, and since that time a program has been initiated to adapt high-speed electronic computing methods to the aircraft analyzer problem. A computer which will solve the aircraft stability equations will have the required capacity for many other families of scientific problems. Consequently, effort at the present time is being devoted to the study and development of general electronic digital computing techniques. Approximately a year and a half will be devoted to studying and developing these methods, by which time their adaptability to the aircraft analyzer problem can be determined.

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could be changed to obtain desirable performance and the aerodynamic properties of the model redesigned to produce these coefficients.

#### 2.35 Aircraft Criteria

The availability of an aircraft analyzer would permit more complete investigations into the characteristics of successful aircraft. With aerodynamic characteristics under control and subject to rapid change, a better appreciation of factors affecting good aircraft performance could be achieved.

#### 2.36 Study of Automatically Controlled Flight

In addition to the study of piloted aircraft such equipment should permit studies of aircraft under the control of automatic pilots as well as studies of guided missiles.

#### 2.4 Flexibility

An analyzer which will solve the problems outlined above will be a computer of considerably greater complexity than any now existing. At first a permanent arrangement of computing elements was contemplated in the manner originally used in the operational flight trainers. It early became apparent that such a fixed schematic would be entirely impractical because the equations to be solved were undergoing continual change and because a computer of this size and potential usefulness should not be committed to a single type of problem. Plans therefore call for as much flexibility as possible in the type of problem to be solved by the computer portion of the aircraft analyzer.

### 3. PRESENT STATUS

#### 3.1 Analogue Computing Summary

The first plan for the computer to solve aircraft stability equations followed the approach previously worked out for fire control computers and differential analyzers. In analogue computation a separate computing element is required for each mathematical step involved in the problem solution. The requirement of a real time

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scale placed new and exacting specifications upon the individual computing components. In most differential analyzers variables are represented by mechanical shaft rotation where several revolutions are required to indicate the maximum excursion of the quantity represented. Since some quantities in the aircraft analyzer will traverse their entire range of operation in a fraction of a second, new high-speed computing elements would be required. A completely mechanical system did not appear practical because of the complexity, the difficulty of interconnection, and the lack of flexibility. Consequently, early studies were devoted to the development of computing elements where quantities would be represented by electrical voltages. Several circuits were developed for an alternating-current carrier type of signal representation. Because the dynamic range of many variables require a signal range that is impractical for electromechanical equipment such as potentiometers, some experimental studies were carried on with a sliding scale factor technique that will be described in the technical part of the report. A computer for solving the aircraft problem by analogue techniques would be many times the size and complexity of any differential analyzer developed thus far. As the aircraft analyzer was studied in detail and certain schematic circuits developed, it became apparent that the following factors cast doubt upon the practicality of an instrument of this type.

### 3.11 Accuracy and Sensitivity

It is doubtful that the required accuracy and sensitivity for the aircraft problem can be maintained through the use of analogue computing equipment built for the required speed of operation.

### 3.12 Complexity

The large number of computing components (See Section 4.7) would lead to a volume of equipment that would present serious maintenance and operating difficulties. Trouble shooting would be difficult and prediction of accuracy nearly impossible.

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### 3.13 Flexibility

The form of the equations describing aircraft motion will be subject to continual change and improvement as wind tunnel and flight test data becomes more accurate or is expressed in different terms. Modification of the equations may be from time to time desirable as studies of the methods of solution progress. To be useful, therefore, even in the solution of aircraft stability problems, a flexible computer schematic must be maintained. For an electrical analogue computer this would mean a plug-board type of interconnection which is not considered desirable for a computer having a large number of elements and requiring the dynamic range which must be associated with the aircraft analyzer equipment.

### 3.14 Limited Application

A computer of the analogue type would be expensive, would require a long development time, and when finished, would be of rather specialized nature and suitable only for a limited class of problems. A computer which represents the investment contemplated for the aircraft analyzer should be so designed that many other classes of scientific problems can be solved.

## 3.2 Digital Computation

Many of the disadvantages attributed to analogue computers can be overcome through the use of numerical analysis methods and electronic digital computation.

### 3.21 Advantages

#### 3.211 Accuracy and Sensitivity

Whereas the accuracy and sensitivity of the analogue computer are limited by the mechanical and electrical tolerances associated with its physical components, the accuracy and sensitivity of a digital computer depend primarily upon the mathematical process selected, the number of digital places carried in computation, and the increments along the independent variable at which solutions are taken.

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### 3.212 Flexibility

A digital computer need not depend upon the physical interconnection or positioning of components for its schematic hookup. Problems are set up through the use of punched cards, tape, or some other prepared form of information. Changes in equations representing particular problems can be readily accommodated as well as making possible changes to entirely different types of scientific problems.

### 3.213 Predictability

Operation of the digital computer is identical except for solution time with the process followed in step-by-step numerical analysis methods. Solutions can therefore be worked out ahead of time for certain examples, using calculating machines and operators. The form and accuracy of a solution can therefore be predicted and will not depend upon physical tolerances and behavior of circuit elements in the computer so long as operation is trouble free.

### 3.214 Scope

The digital computer may be applied to many problems to which the analogue computer would not be applicable.

In this computer attention is being centered on applied science and engineering. Emphasis will be placed on its adaptation to dynamic systems such as aircraft, automatic fire control, and servomechanisms.

Application to algebraic equations will be studied. For the present, the solution of partial differential equations will receive only secondary interest until electronic techniques are under control.

## 3.22 Disadvantages of a Digital Computer

### 3.221 Development Time

Development time for a digital computer will be perhaps longer than for an analogue type system.

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3.222 Cost

Development cost for a digital computer will be high and rather difficult to estimate although construction cost should be lower than for the analogue system.

3.223 Parallel Operation

In order to solve the aircraft stability equations in real time, some parallel operation of electronic computing elements will probably be necessary, thereby leading to more complicated circuits than might otherwise be required.

3.23 Proposed Approach3.231 Binary System

At the present time it is anticipated that computation will be done in the binary system of notation. For the aircraft analyzer itself this represents no difficulty since results will be derived as graphical representations and conversion from the decimal system will not be required except in setting up a problem. For other types of scientific computation input and output conversion with required recording equipment must be developed.

3.232 Serial Operation

Insofar as possible, computing operations will be done in a serial manner. The digits of a number will be transmitted consecutively over the same circuit and identified by their location in time. Some parallel operation may be required such as computation occurring simultaneously with the setup of the next step and perhaps simultaneously with certain subsidiary operations, such as interpolation for coefficients. Multiplication time will be reduced by parallel computation.

3.233 Operating Speed

At the present time operation is contemplated with the use of  $1/4$  microsecond video pulses to represent binary digits with a 1 megacycle repetition rate. Preliminary investigations are

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being carried on at a 100 kilocycle repetition rate and studies will be made to check the feasibility of rates above one megacycle.

### 3.234 Electrostatic Storage

Storage of partial solutions will be attempted by means of electrostatic storage tubes. Because of the computing speed required in problems involving real time, a storage method permitting immediate insertion and withdrawal of stored data is desirable. Storage by supersonic delay techniques may be used in certain places if advantages are demonstrated for this type of storage.

## 3.24 Research Problems

### 3.241 Storage

It is anticipated that 200,000 to 500,000 binary digits must be stored in this computer. This total represents both the program, the storage of fixed quantities, function tables and coefficients, and the storage of partial results. The two former categories can use semi-permanent storage as distinguished from high-speed electrostatic storage.

### 3.242 Program

Program control techniques for the computer must be developed which will take information from a semi-permanent form of representation and use it for control of high-speed storage and computing processes.

### 3.243 Computer

Computer circuits for addition, subtraction, multiplication, and division will be required as well as perhaps a special unit for interpolation in order that solution time can be conserved. Other arithmetical and algebraic operations may be programmed in terms of these basic steps.

### 3.244 Checking

Checking and trouble shooting procedures must be established and built into the computer.

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3.245 Recording

Several forms of recording will be required on the computer output. Problems involving low final accuracy and particularly those representing solutions versus time can be recorded as oscillograms. Other types of problems may require card punching, automatic typewriters, highspeed photographic recording, and magnetic recording.

3.246 Signal Conversion

Projects such as the aircraft analyzer will require methods for converting mechanical shaft rotation to binary digits in order that the transition between cockpit and computer may be accomplished.

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PART B - TECHNICAL4. AERODYNAMIC EQUATIONS4.1 Report H-64

The aerodynamic equations as now visualized for representing the control and stability characteristics of an aeroplane in flight are given in DIO 6345 Report 64 which, along with equation schematics, is included in Appendix A. This report is the outgrowth of work by staff members of the Wright Brothers Wind Tunnel at M.I.T.

4.2 System of Axes

The general problem of solving for the motion in space involves the solution either of the equations describing the resultant motion or the equations describing components of the resultant motion along and about some system of axes. The approach to the problem has been to set up equations describing the motion along and about a 3 co-ordinate axes system called body axes with the origin at the airplane's center of gravity. The body axes very nearly coincide with the principal axes, thus the product of inertia terms are considered negligible. Motion of the airplane in space is related to the earth axes through a set of Euler angles. Thus nine simultaneous integral equations are required to determine the motion of the airplane in space and to relate it to the earth axes. The relative wind direction, found trigonometrically, determines the wind axes. See Appendix A.

4.3 Landing and Take-Off Equations

The general empirical functions which describe reactions on the airplane exclude ground reactions and complicated reactions in stalled flight. As a result, special terms for the take-off, landing, and stall representations are included in the equations. Since it is desirable to maintain a continuous solution through transition from one flight condition to another and to minimize the complexity of representation, several simplifying assumptions and several limitations on the equations have been made.

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4.31 Take-Off and Landing Representation

The take-off and landing is considered in two sections:

1) aerodynamic reactions, and 2) ground reactions.

4.311 Aerodynamic Reactions

The fact that  $T_c'$  goes to infinity at zero speed requires that those aerodynamic reactions which are a function of  $T_c'$  must be modified during the ground run. The description of the general aerodynamic data is limited to a reasonable value of  $T_c'$  and additional functions are added which describe the aerodynamic effects above the specified maximum  $T_c'$ .

4.312 Ground Reactions

The following assumptions are made for the ground run:

- a) No cross wind; angle of yaw remains zero, but heading can change. Relative wind remains along intersection of planes XOZ and AOB.
- b) No rolling moment occurs. Wings remain level during ground run.
- c) No sideforce occurs.
- d) No sideslip between wheels and ground.
- e) No weight is carried by either nose or tail wheel. Weight is distributed equally on the two main wheels.

With the above assumptions, the ground reaction terms, including braking effects, can be computed and added to the equations. These terms either go to zero or cut out of the solution when the altitude is greater than zero. In the same manner, for instance, the rolling moment which remains zero during the ground run, requires that the equation for  $L/I_x$  be cut out of the continuous solution until such a time as the altitude is greater than zero.

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#### 4.4 Stall Conditions

The representation of the stall in the analyzer will not be complete since the motion in the stall is not to be studied. Therefore, the effect desired is to provide a stall warning, such as control buffeting, to let the pilot be aware that the airplane is stalling, provide a means of control during the stalled period, and have the airplane emerge from the stall at some angle of attack and lift coefficient below the stall.

#### 4.5 Control Forces

To make the illusion of flying as nearly complete as possible, it is necessary that control column and wheel, and rudder pedal forces have the proper feel. In addition, for a particular airplane, the forces and variation of forces should be reasonably correct for all flight conditions. Equations are set up to solve electrically for the hinge moments at the control surface hinges. If the electric impulses corresponding to the hinge moments are transformed to a force, this force could act through a system of mechanical linkages similar to the actual control linkages to give the proper control feel. In this manner, the effects of friction, cable stretch, and inertia effects of the actual airplane control system can be included. To date, no provision is made to compute the dynamic characteristics of the control surfaces.

#### 4.6 Engine Simulation

The analyzer will be set up to simulate a four-engine airplane. It is necessary to simulate reciprocating engines, gas turbines, jet units and combinations thereof. It is hoped to find a general representation to compute thrust for any type of engine. Since the analyzer is basically to study airplane stability and control, and not airplane performance, it is not required to simulate the engines exactly; i.e., to obtain the thrust which gives the desired cruising speed, it is not necessary to have the manifold pressure and RPM exactly correct.

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4.7 Summary of Computations

The following is a summary of the number of mathematical operations indicated by the aircraft equations of Appendix A.

	<u>A</u>	<u>B</u>	<u>C</u>
Multiplication of two variables	105	11	149
Multiplication of a variable by a constant	103	6	127
Additions and Subtractions	179	7	207
Divisions	8	3	20
Reciprocals	9	0	9
Integrations	10	0	10
Trigonometric functions	9	0	9
Inverse Trigonometric functions	4	0	4
Square Roots	2	0	2
Non-Integral Exponentials	1	0	1

Column A includes the operations indicated by equations 1 through 56 and 80 through 90, which are the equations of motion, hinge moment equations, aerodynamic coefficient equations, instrument equations, and miscellaneous. Column B includes the operations indicated by equations 57 through 80, which are the engine equations. Column C is a total of all operations for a four engine airplane.

The following assumptions have been made in compiling this tabulation:

- (a) Where two or more divisions by a function or quantity are required, the reciprocal can be found and then multiplied to reduce divisions.
- (b) Reciprocal quantities which remained constant during the Analyzer operation or

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were set manually by the Flight Engineer were introduced with the assumption that the reciprocal had been calculated external to the computer.

- (c) This tabulation does not count any specific operation more than once.
- (d) No operation for finding values of functions of computed values from curves or function tables are included.
- (e) Additions and subtractions are tabulated together since there is no essential difference in these operations.
- (f) Each operation involves two quantities only, so the sum of three quantities is two additions, etc.
- (g) Integral powers are called multiplications, thus  $a^2 = a \cdot a$ .

## 5. DYNAMIC RANGE AND ACCURACY

Only estimates have been thus far arrived at for the dynamic range, sensitivity and accuracy required for the computing equipment to be used in a solution of the problem of aircraft motion. Some of these estimates are given in DIC 6295 Report 49.

### 5.1 Pitching Angular Velocity

Flight tests show pitching velocities as great as  $\pm 30^\circ$  per second in certain necessary flight test maneuvers. Although flight test procedures no longer pay great attention to a determination of the period and damping of the phugoid or long period longitudinal oscillation, an airplane, if disturbed from its trim angle and thereafter uncontrolled, will pitch in accordance with this mode of its oscillation, and it should be reproduced for such a time as the pilot might leave the analyzer uncontrolled. This involves a very small

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angular velocity which might be as small as  $0.1^\circ$  per second. If such a motion is to be accurately generated, the equipment must be sensitive to a much smaller velocity change. Ideally one might wish to have sensitivity to  $1/60$  of this velocity or to  $1/600$  degree per second. Thus the ratio of maximum to minimum velocities might be as high as 18000:1.

#### 5.2 Factor of Safety for Aircraft

The maximum value of pitching velocity of  $30^\circ$  per second used in the above example is based on existing aircraft and does not allow a factor of safety for future aircraft or missiles which might increase its value.

#### 5.3 Factor of Safety in Computation

The above observations on required dynamic range of computing equipment does not include a factor of safety for significant figures lost in the computing components themselves. It is readily seen that mechanical and electrical equipment for analogue computation can hardly have a factor of safety above the dynamic range indicated in 5.1 and 5.2.

#### 5.4 Electrical Signal Range (Analogue Computer)

Since the electronic computing components were being designed around conventional vacuum tubes and their circuits including cathode followers, a maximum A.C. signal amplitude of approximately 40 volts seemed desirable. A dynamic range of 20,000 to 1 would then require a minimum detectable signal of 0.002 volts.

Difficulties in obtaining the required dynamic range for signals are immediately apparent.

##### 5.41 Shielding

Very careful shielding would be necessary to maintain noise levels of 1 millivolt or less on signal lines carrying maximum values of 40 volts.

##### 5.42 Power supplies

Power supplies must be regulated to a few millivolts of ripple to prevent the introduction of extraneous signals.

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5.43 Sliding Scales

Computing elements requiring mechanical equipment such as potentiometers must have precision gear trains and, even so, must operate with a sliding scale factor based upon some assumption of permissible reduction in sensitivity with increase in signal level.

5.5 Extension of Analogue Operating Range

Since the required signal range of an analogue type computer using voltages to represent variable quantities can probably not be realized, certain alternatives must be considered. One of these is the division of a problem into several phases of investigation. For example, the aircraft take-off conditions might be studied with an expanded set of scale factors for those variables which have only limited range. Again, straight and level flight conditions could be studied with high sensitivity by setting up the analyzer specifically for this problem. Lastly, maneuvering conditions could be represented by setting up the problem for maximum range of variables. These alternatives are undesirable since they place a greater burden upon the investigators who set up a problem, because operation of the aircraft analyzer becomes more difficult, and because continuity of flight is lost along with its psychological effects upon the test pilot.

6. NON-LINEAR COEFFICIENTS

Many of the aerodynamic coefficients shown in Appendix A are non-linear and depend upon values of variables being computed by the analyzer. The following tabulation summarizes the number of these variable coefficients.

<u>Functions of</u>	<u>Engines</u> (Equations 57-79)	<u>Hinge Moments</u> (Equations 23-25, 40-48)	<u>Others</u>	<u>Total*</u>
One variable	2	4	15	27
Two variables	6	6	20	50
Three "	0	7	9	16
Four "	0	1	1	2
Five "	0	1	0	1

\* Total for four engines.

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### 6.1 Examples

The following examples of non-linear coefficients are included and discussed in Appendix B:

$f_1 (\alpha, \delta F, T_c') =$  largest term of lift coefficients

$f_4 (\alpha, m_n) =$  term in lift coefficient caused by large mach numbers, i.e., very high speed

$f_7 (\delta R, \delta) =$  term in drag coefficient caused by rudder deflection

$f_{13} (\alpha, T_c' - T_c') =$  term in pitching moment coefficient caused by unsymmetrical thrust

$f_{19} (\delta R, T_{c_{2+3}}') =$  term in yawing moment coefficient caused by rudder

### 6.2 Representation of Non-Linear Coefficients

Several methods of representing non-linear coefficients immediately come to mind.

#### 6.21 Cams

Cams are perhaps the oldest form used in fire control computers. These would be too cumbersome for the aircraft analyzer because of the difficulty in cam cutting, the irregular shapes of some coefficients, the large number of variables involved in some functions, and the problem of inserting cams into the analyzer in the set-up of a new problem.

#### 6.22 Tapered Potentiometers

Tapered potentiometers could be used for functions that did not require frequent alteration. However, since most coefficients will vary considerably from one aircraft problem to another, the use of tapered potentiometers is rather impractical.

#### 6.23 Networks

Some studies have been made by Bell Telephone Laboratories and this group in adapting electrical resistance networks using static

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elements and potentiometers for the computation of non-linear functions. While this method shows some promise, it is difficult to set up, cumbersome to execute in practice, and lacks the flexibility which should be associated with this equipment.

### 6.3 Tapped Potentiometers

The use of tapped potentiometers showed the best promise for representation of variables in an analogue computer making use of electrical voltages to indicate signals. These potentiometers were planned to have several taps at which would be established voltages corresponding to the function at the tap position on the potentiometer. These voltages would be established perhaps through a punch card system and cathode follower vacuum tube circuits. Such a system can be extended to several variables. Function representation is based on the assumption that linear interpolation between points of data is satisfactory. Some tests were made with tapped potentiometers having several sliding brushes with resistance networks for smoothing curves at the points of discontinuity in slope. These methods showed promise but studies were not carried to completion.

## 7. ANALOGUE CIRCUITS

### 7.1 Alternating Voltage Carrier

Analogue computing circuits studied in the early phase of this work were based entirely on the use of alternating voltage carrier to represent variables. Work was done at 60 cycles and considerable interference was encountered between power supply ripple and signals. Phase shift between signals on the input of summing amplifiers was a problem, as could be expected. An alternating current system was initially selected because the problem seemed less formidable than those associated with direct current amplifiers and their power supply problems. A network of approximately 12 summing amplifiers was constructed to

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represent equations 1, 20, and 29 in Appendix A. This network did not involve servo-driven multiplier units but used static potentiometers at the points indicated for multiplication of two variables. Noise levels in this network were held to about 1 millivolt and the required dynamic range outlined in Section 6 were obtained although considerable difficulty was experienced. Phase shift between carriers was particularly noticeable at summing amplifiers where signal subtraction was taking place. Large quadrature and harmonic signals were found at the amplifier outputs. These might be tolerable in many cases because signals eventually fed servo systems at multipliers or integrators which are fundamentally insensitive to quadrature voltage.

#### 7.11 Summing Amplifiers

Several types of circuits were investigated for summing A.C. signals, and a reasonably satisfactory amplifier was developed and tested in the demonstration units. The essential features consisted of bringing the signals to be added (up to five in number) in, through isolating cathode followers, summing the signals by ordinary current addition methods in a single grid resistor, and then raising this total signal to the correct voltage and impedance level through a feedback stabilized amplifier. The accuracy of summing with good matching of input and output impedances is of the order of one-fourth per cent. The dynamic range was about 1 to 30,000 from minimum to maximum signal and the output distortion was usually less than 2% total harmonics. The phase shift except for very small signals was less than one degree for 60 cycle signals. It seems probable that these summing amplifiers, with certain modifications suggested by the tests, would have been entirely satisfactory for the contemplated analogue computer.

#### 7.12 Integrators

Two approaches to the integrator problem were investigated.

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7.121 Mechanical

A two-stage mechanical integrator using ball and disc integrators from fire control equipment were arranged in a manner similar to that indicated for the multiplier in Appendix C. Results from these units were not up to expectation, largely because of mechanical back-lash and other operating imperfections. It is anticipated that these imperfections might not be reducible to a level that would permit desired performance.

7.122 Electronic

An electronic integrator for alternating voltages was studied, based upon the use of feed-back amplifier techniques and Brown Instrument Company vibrators for the conversion of D.C. voltages to A.C. In this circuit integration was performed in a direct current R-C stage. The output condenser voltage was converted with a vibrator to 60 cycle A.C. and the resistance drop was converted to A.C. for comparison with the input signal. The difference between input and resistance drop was fed to a high gain A.C. amplifier, the output of this amplifier being converted to D.C. for operation of the integrating circuit.

Research on this integrator was likewise not carried to completion. Other promising integrators have been developed by various laboratories which would have been investigated before making a final selection of method.

7.13 Multiplication

Analogue multiplication of electrical signals was planned with potentiometers and servo units. The potentiometer slide would be driven proportional to one signal while the second signal would be applied to the potentiometer winding. To obtain the required dynamic range, a two-stage multiplication would be used where one potentiometer would set the scale factor for multiplication by the second potentiometer as shown in Appendix C. Because of the high accelerations and velocities

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experienced by the variables of the aircraft analyzer problem, it would be necessary in an analogue machine to have high-speed servo units to drive the multiplying potentiometers.

#### 7.14 Frequency Modulated Servo

A servo system for computer operation was experimentally studied for high static accuracy and high natural frequency. This servo system operated with a polyphase, low-slip induction motor driven from a variable frequency source capable of continuous output between the limits of positive and negative (reverse phase rotation) frequency required for maximum motor speed. This servo system is discussed more fully in Appendix D.

#### 7.2 AC versus DC Signals

Only studies of an AC carrier system for signal voltages had been conducted on this project prior to the transfer of attention to digital computation. It has not been clearly established how the disadvantages of AC carrier systems, particularly phase shift and power supply ripple, compare with the problems encountered in direct current amplifier systems. It is felt that work carried on by Columbia University using direct current amplifiers, multipliers, and integrators has been carried to a higher state of development and may well be more desirable than the AC system for computers within the size range suitable for analogue computation.

### 8. WIND TUNNEL TESTS

The data describing the aerodynamic reactions of a particular airplane requires extensive wind tunnel testing. In the Wright Brothers Wind Tunnel results are obtained, referred to wind axes, and are recorded manually. All results are static and no tests to determine rotary derivatives are made. In addition the hinge moment results on small scale models are inconclusive.

Extensive redesign of the balance and recording system will incorporate provisions 1) for testing for rotary derivative, 2) for automatic

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data reduction and recording and 3) for obtaining data about stability axis. Tests on large panel models of the control surfaces will provide more accurate hinge moment data, and some actual flight testing may be done for correlation work in determining dynamic characteristics.

#### 8.1 Data for Model A

The equations of motion as now set up in Report 64 include the equations for the aerodynamic coefficients. The component functions of these coefficients has been compiled for a twin engined airplane designated Model A. These data, results of actual test for the most part, have been used in preliminary calculations and are representative both in type and quantity of what the analyzer must handle. See Report E-98. At present moment coefficients are given about body axis and force coefficients along wind axes. The equations are set up in the analyzer to transfer the force coefficients to the body axes system. It seems advisable at the present time, however, to convert all coefficients to the body axes reference before it reaches the analyzer.

### 9. COCKPIT DESIGN

The aircraft analyzer problem, as visualized for an analogue computer, required a cockpit having sufficient realism to provide the illusion of flight to the test pilot. Much progress in this direction has been made by the Bell Telephone Laboratories in their Operational Flight Trainer. Further improvement over these units is necessary not only in the instrument readings which depend primarily on the computer but also in the generation of control reaction forces.

#### 9.1 Cockpit Mounting

Operational Flight Trainers have been built and operated effectively without provision for cockpit motion. Less elaborate trainers, such as those built by Link, have used cockpit motion to good advantage.

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### 9.11 Tilt

It is proposed that the cockpit for the aircraft analyzer be mounted to provide tilting in pitch and roll which will provide the necessary simulation of apparent change in gravity direction. With the cockpit mounted as shown in Drawing C-30053 the effects of side slip, horizontal acceleration, and pitch angle can be simulated. Cockpit angular motion is discussed more completely in 6345 Report No. R-100.

### 9.12 Vertical Motion

A small amount of cockpit vertical motion may be provided to divorce the cockpit from the rigidity of a fixed support and to produce the illusion of air-borne motion.

### 9.2 Control Force Equipment

A hydraulic force generating system was designed for the simulation of rudder, elevator, and aileron forces. This system was sensitive to forces of a fraction of a pound on the control column and could generate forces of several hundred pounds. It is described in 6345 Reports Nos. R-36, R-37, R-38, R-96, and R-99. The equipment will be redesigned into a packaged form when required for the aircraft analyzer.

### 9.3 Instrument Arrangement

Only tentative cockpit instrument and control column arrangements have been studied. When a final design is prepared, it will be in line with the proposal of the Navy Committee on Standardization of Aircraft Cockpits.

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APPENDIX A  
to

PROJECT  
WHIRLWIND  
(DEVICE RF-12)

SUMMARY REPORT NO. 1  
April 1946

REPORT R-64  
Revision 1 - Dated April 4, 1946  
on  
Aircraft Stability and Control Equations  
follows on the next 30 pages

- - -

NOTE: Drawings R-30011  
D-30012  
D-30013

show schematic arrangement  
of the equations in Report  
R-64 before Revision 1.

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6345  
Report R-64,  
Revision 1

SERVOMECHANISMS LABORATORY  
Massachusetts Institute of Technology  
Cambridge, Massachusetts

Date of Revised Report: April 4, 1946      Page 1 of 30 pages  
Date of Original Report: October 31, 1945      Figures: 1-2-3-4  
Subject: ASCA Equations (Revised - October 30, 1945  
April 4, 1946)

References: Original Copy - J. W. Forrester's file  
Authors: L. Bernbaum - both of WBWT  
J. Bicknell

This report supersedes the information in Report 50 and Report 64 dated October 31, 1945. It is supplemented by Reports 15, 18, 49, 58, 62, and R-98.

It is the object of this report to include under one cover all the symbols and equations to be incorporated in the analyzer, and to describe the progress of equation development to date. Progress has carried the study to a point where equations, functions, and constants can be assigned definite numbers. Therefore, all symbols and numbers assigned in this report will be considered as official reference in the future.

The types of equations requiring solution in the analyzer are classified as follows:

1. Basic equations of motion	1 - 6
2. Equations relating wind, body, and earth axis	7 - 15
3. Auxiliary equations of motion	16 - 21
4. Control surface hinge moment equations	22 - 25
5. Auxiliary equations or aerodynamic coefficient equations	26 - 48
6. Instrument equations	49 - 56
7. Engine equations (for one engine)	57 - 79
8. Miscellaneous	80 - 90

1, 2      The basic equations of motion and the equations relating wind, body, and earth axis have been rewritten as integral equations instead of differential equations. See equations 1 - 15 and Figs. 1, 2.

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Report R-64,  
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Several of the circuits require special consideration to determine when they must or must not be included in the general solution, or held in or out for a specified time. The special cases of take-off and stall are examples of unusual computing procedures. Reports describing the operations desired will be issued in the future.

3. The only change made to the auxiliary equations of motion describing the linear accelerations along wind axes is the addition of the take-off terms. It must be noted, however, that equation 17 describing the acceleration along  $OY$  has no component of engine thrust included. The thrust component, which acts along the  $OX$  body axis is computed from the engine data and fed into the basic equation of motion describing the linear acceleration along  $OX$ .

The auxiliary equations of motion describing the angular accelerations, numbers 19, 20, 21, about body axes have had some terms added. Reduction of moments due to deflections of the airplane structure under load have been included. These reductions have been taken as functions of the horizontal tail, vertical tail, and aileron loads. Since rolling moments produced by the ailerons are already computed in equation 31, an expression is included in this equation to reduce the net aileron moment produced. The pitching and yawing moments reductions, however, cannot be handled as simply. It will be necessary to compute the moment coefficients produced by the horizontal and vertical tail, equations 38 and 39, and subtract out some percentage of these in equations 19 and 20. The percentage reductions will be constant for a given airplane.

The rotary derivatives, or moments produced by a rotation are included in equations 19, 20, 21. These terms require a separate equation to determine each derivative.

The angular momentum of the propellers is great enough to produce a measurable pitching or yawing moment when either a yawing or pitching velocity occurs. They appear in equations 19 and 20 divided by the appropriate moments of inertia.

Also included in equations 19, 20, and 21 is provision for a center of gravity shift in any direction. All moment data furnished from the wind tunnel will be about the wind tunnel balance resolving center. This point will correspond to some point on the airplane, which will be a reference point. All C. G. positions will be specified in percent of the aerodynamic chord away from the reference point. See Fig. 3.

Equation 20, for the yawing acceleration, has included the direct thrust effect due to unsymmetrical engine operation.

The diagram, Fig. 4, showing the horizontal and vertical distances of the C. G., from the point of main wheel contact, describes the moment arms which determine the moments due to the ground reaction terms. This diagram supercedes the sketch of ground angles in Report 50.

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4. Hinge moment equations 22, 23, 24 replace the original control force equations. One method to handle the control loading is to solve electrically for the hinge moments at the control surface hinges and apply these to a system of mechanical linkages similar to the actual airplane linkage. In this manner, friction, cable stretch, and inertia effects of the actual airplane control system can be included physically. Report 58 covers this subject of control loading.

5. The auxiliary equations or aerodynamic coefficient equations have been altered considerably in order to conform to the proposed point by point method of data representation. These are equations 26 - 48 and sample curves for a particular airplane representing the various functions in the auxiliary equations will be included in a future report. (See R-98.)

The auxiliary equations to determine the rotary derivatives, equations 32 - 37, have been multiplied by a non-dimensional number which includes the airplane velocity, thereby reducing by one the variables on which the rotary derivatives are dependent. Thus, if the rolling moment due to a rolling velocity  $\frac{\delta C_l}{\delta p}$  is a function of  $\alpha, \delta, \delta F, V$  then  $C_{l_p} \left( \frac{pb}{V} \right)$  is a function of  $\alpha, \delta, \delta F$  if  $C_{l_p}$  is defined as  $\left( \frac{V}{b} \right) \left( \frac{\delta C_l}{\delta p} \right)$ .

Two types of additional functions have been added to the auxiliary equations. The first is a function of the Mach number (the ratio of airplane speed to speed of sound) included in the lift, drag, and pitching moment coefficients equations. These functions have been considered necessary for a more rigorous solution at the high speeds encountered in modern aircraft. Inclusion of a Mach number term may be considered as a correction term, and therefore the functions describing such terms will be of limited complexity; i.e., the function will be described only at relatively low angles of attack.

To include terms in the auxiliary equations as functions of the Mach number, it is necessary to continually compute the value of the Mach number; i.e., the velocity  $V$  divided by the velocity of sound  $V_s$  at the particular altitude in question. The velocity of sound as a function of altitude is given in Report 62.

The second type of functions added have been termed manual settings and can be distinguished by the symbol  $M_x$  used to describe the constant of each term. On any airplane, the data initially will be set according to results of wind tunnel tests. After operation of the analyzer, however, it may be convenient to change some parameters at will in order to determine qualitatively the manner in which the configuration of the airplane should be changed in order to obtain more desirable characteristics. These parameter changes will be simple slope changes or additions and should be readily adjustable, preferably by means of dials located on the control engineer's panel. All such adjustments will be set at zero for the initial tests.

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The control engineer acts in the capacity of the flight engineer of the airplane. He creates flight problems, and handles those matters for which automatic equipment has not been included. The latter would be cowl flap settings and engine head temperatures, bomb doors, etc.

The following list of controls at the control engineer's desk is an indication of the type of control; a complete list will be given in future reports.

1. Change of mass
2. Change of horizontal C.G.
3. Change of vertical C.G.
4. Change of lateral C.G.
5. Change of moment of inertia about ox axis ( $I_x$ )
6. Change of moment of inertia about oy axis ( $I_y$ )
7. Change of moment of inertia about oz axis ( $I_z$ )
8. Change of outboard port engine power including engine failure
9. Change of inboard port engine power including engine failure
10. Change of inboard starboard engine power including engine failure
11. Change of outboard starboard engine power including engine failure
12. Provision for gusty air
13. Change of ground friction coefficient

Certain of the above manual adjustments will entail automatic changes in other parameters. Thus, several new equations are required. They involve:

1. Changes in moments of inertia when mass is changed
2. Changes in moments of inertia when C.G. is changed
3. Change of thrust component with feathered propeller

These will be considered in detail in a future report.

Included in the aerodynamic effects which determine the resultant motion of the airplane are the stall phenomena. To continuously simulate the motion in the stall is too highly involved for the end result achieved. It has been decided, therefore, that the effect desired in the analyzer is to let the pilot be aware that the airplane is stalling, give him some means of control during the stalled period, and have the airplane emerge from the stall at some angle of attack and lift coefficient below the stall.

Some stall warning such as buffeting of the controls should appear before the stall is reached.

It is proposed to achieve this stall as follows:

1. A function of  $\delta F, T_c'$  will determine the stall angle of attack. Stall occurs when  $\alpha = \alpha_{stall}$ .

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2. At each stall angle, a drop-off in  $C_L$  will occur depending on the severity of the stall.  $C_L$  will be held constant at its new value until such a time that  $\alpha$  decreases, returning itself to the lift curve for normal operation.
3. At each stall angle, decrease aileron effectiveness (probably same amount for all cases) until recovery is reached.
4. At each stall angle, apply suddenly a  $C_n$  and  $C_y$  proportional to the severity of the stall. These increments are to be applied for a definite time interval and removed.

During the stall, all machinery will continually compute the motion so that at recovery the airplane will be under normal operation.

Handling the take-off will be considered in detail in a future report. It is well to note, however, that several of the equations which determine the aerodynamic coefficients have  $T_C$  included as a variable and therefore cannot be used for take-off computations because  $T_C$  goes to infinity at zero airspeed.

The proposed method for handling this difficulty is to add data to the equations of motion based on thrust and velocity during take-off. This data will be in dimensional form, and ground reaction effects will be included. Fig. 4 supercedes the previous sketch describing the ground angles in Report 50. Certain assumptions made for the take-off run simplify the amount of data required. These assumptions are:

1. Angle of bank is zero
2. Angle of yaw equals zero
3. No side slip between wheels and ground

After take-off, the proximity of the ground affects the aerodynamic reactions, particularly the longitudinal stability. This effect is included in equation 29 for  $C_m$  which has a term added that increases the basic longitudinal stability as a function of altitude and goes to zero when  $h = b$ .

7. Engine simulation equations will be obtained for four reciprocating engines, for gas turbines with jets and propellers, for jet engines alone, and for jet and reciprocating units combined.

The reciprocating engines and propeller is treated as a unit. From a knowledge of the airplane velocity  $V$ , altitude  $h$ , density  $\rho$ , pressure  $P$ , and the engine control settings, the thrust is computed.  $T_C$  etc., is also computed to be supplied to the auxiliary equation functions.

The number of separate equations to be solved for each reciprocating engine to obtain the thrust output (for the present torques will be neglected) is 23, 92 equations for four engines. These equations are listed, numbers 57-79 for one engine. Their explanation and synthesis into the analyzer will be given in a later report. Additional equations for jets and gas turbines will be added at a later date.

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No account in the engine equations is taken for the fact that each engine operates at a different  $\frac{V}{V_D}$  when a yawing velocity occurs.

The effect is to produce a damping moment due to the rate of yaw by decreasing the thrust on the engine going forward and increasing it on the engine going rearward. The yawing moment produced results then from a yawing velocity, and thus can be handled in the equation for the rotary derivative  $C_{n_r}$ . This method simplifies the engine equations somewhat by having each engine operate at the same forward speed.

It is planned that the engine circuits will include a suitable system to simulate engine noise and the accompanying vibrations.

For schematics, function chart and interconnection of equations see 6345 drawings:

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D-30012  
D-30013  
E-30014  
D-30015

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EQUATIONS OF MOTION  
ANGULAR VELOCITIES ABOUT BODY AXES

$$(1) \quad \dot{\gamma} = \int_0^t \left[ \frac{M}{I_Y} + \left( \frac{\bar{c}-\bar{a}}{\bar{b}} \right) \dot{\gamma} p \right] dt$$

$$(2) \quad \dot{\gamma} = \int_0^t \left[ \frac{N}{I_Z} + \left( \frac{\bar{a}-\bar{b}}{\bar{c}} \right) \dot{\gamma} p \right] dt$$

$$(3) \quad \dot{p} = \int_0^t \left[ \frac{L}{I_X} + \left( \frac{\bar{b}-\bar{c}}{\bar{a}} \right) \dot{\gamma} \dot{\gamma} \right] dt$$

LINEAR VELOCITIES ALONG BODY AXES

$$(4) \quad \dot{u} = \int_0^t \left( -\dot{\gamma} \sin \theta + \frac{x}{m} + \dot{\gamma} v - \dot{\gamma} w \right) dt$$

$$(5) \quad \dot{v} = \int_0^t \left( \dot{\gamma} \cos \theta \sin \phi + \frac{y'}{m} + p w - \dot{\gamma} u \right) dt$$

$$(6) \quad \dot{w} = \int_0^t \left( \dot{\gamma} \cos \theta \cos \phi + \frac{z'}{m} + \dot{\gamma} u - p v \right) dt$$

VELOCITY RELATIONSHIPS BETWEEN WIND AND BODY AXES

$$(7) \quad V = \sqrt{u^2 + v^2 + w^2}$$

$$(8) \quad \tan \alpha = \frac{w}{u}$$

$$(9) \quad \sin \delta = -\frac{v}{V}$$

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## EQUATIONS RELATING BODY AND EARTH AXES

$$(10) \quad \theta = \int_0^t (q \cos \varphi - r \sin \varphi) dt + \theta_0$$

$$(11) \quad \varphi = \int_0^t (p + q \sin \varphi \tan \theta + r \cos \varphi \tan \theta) dt$$

$$(12) \quad \psi = \int_0^t \left( q \frac{\sin \varphi}{\cos \theta} + r \frac{\cos \varphi}{\cos \theta} \right) dt$$

## COMPOSITION OF ACCELERATIONS ALONG BODY AXES

$$(13) \quad \frac{X'}{m} = \frac{\Delta}{m} \cos \alpha \cos \gamma + \frac{F}{m} \sin \gamma \cos \alpha - \frac{\lambda}{m} \sin \alpha + \frac{T}{m} + \frac{T_V}{m}$$

$$(14) \quad \frac{Y'}{m} = -\frac{\Delta}{m} \sin \gamma + \frac{F}{m} \cos \gamma$$

$$(15) \quad \frac{Z'}{m} = \frac{\Delta}{m} \sin \alpha \cos \gamma + \frac{F}{m} \sin \alpha \sin \gamma + \left( \frac{\lambda}{m} \right) \cos \alpha - \left( g + \frac{\lambda}{m} \right) \cos \theta$$

|-----GROUND REACTION-----|

## AUXILIARY EQUATIONS OF MOTION

$$(16) \quad \frac{\lambda}{m} = -C_L \frac{e/2 V^2 S}{m} + \frac{f_a(T, V)}{m}$$

|-----GROUND\*-----|

$$(17) \quad \frac{\Delta}{m} = -C_D \frac{e/2 V^2 S}{m} - \left[ \mu + K_a (BP_R + BP_L) \right] \left( g + \frac{\lambda}{m} \right)$$

|-----GROUND REACTION-----|

$$(18) \quad \frac{F}{m} = C_F \frac{e/2 V^2 S}{m}$$

\*EFFECT OF ENGINE THRUST DURING TAKE-OFF.

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$$\begin{aligned}
 (19) \frac{M}{I_Y} = & \left[ C_m + C_{m_q} \left( \frac{q c}{V} \right) + C_{m_{\dot{\alpha}}} \left( \frac{\dot{\alpha} c}{V} \right) \right] \left( \frac{e v^2}{2} \right) \left( \frac{s}{m} \right) \left( \frac{c}{b} \right) \left( \frac{1}{b \bar{b}} \right) \\
 & + \underbrace{\frac{f_b(T, V, \delta E)}{b m b^2}}_{\text{GROUND}^*} - R_M C_{m_t} \left( \frac{e v^2}{2} \right) \left( \frac{s}{m} \right) \left( \frac{c}{b} \right) \left( \frac{1}{b \bar{b}} \right) \underbrace{\hspace{10em}}_{\text{STRUCTURAL DEFLECTION}} \\
 & + \underbrace{\left[ \frac{H}{c} \times \frac{Z'}{m} - \frac{D}{c} \times \frac{X'}{m} \right] \left( \frac{c}{b} \right) \left( \frac{1}{b \bar{b}} \right) + \left( \frac{K_b n \lambda}{m} \right) \left( \frac{1}{b} \right) \left( \frac{1}{b \bar{b}} \right)}_{\text{DISTANCE, C.G. TO REF.} \rightarrow \text{PROPELLER}} \\
 & + \underbrace{\left\{ \frac{H'-H}{c} + \frac{D'-D}{c} \left[ \sin \theta - \mu + K_d (B P_R + B P_L) \right] \right\} \left( g + \frac{\lambda}{m} \right) \left( \frac{c}{b} \right) \left( \frac{1}{b \bar{b}} \right)}_{\text{GROUND REACTION}}
 \end{aligned}$$

$$\begin{aligned}
 (20) \frac{N}{I_Z} = & \left[ C_n + C_{n_q} \left( \frac{q b}{V} \right) + C_{n_p} \left( \frac{p b}{V} \right) \right] \left( \frac{e v^2}{2} \right) \left( \frac{s}{m} \right) \left( \frac{1}{b \bar{c}} \right) + \underbrace{\frac{f_c(T, V, \delta R)}{c m b^2}}_{\text{GROUND}^*} \\
 & - R_N C_{n_t} \left( \frac{e v^2}{2} \right) \left( \frac{s}{m} \right) \left( \frac{1}{b \bar{c}} \right) + \underbrace{\left[ \frac{G}{c} \times \frac{X'}{m} - \frac{H}{c} \times \frac{Y'}{m} \right] \left( \frac{1}{b \bar{c}} \right) \left( \frac{c}{b} \right)}_{\text{STRUCTURAL DEFLECTION} \rightarrow \text{DISTANCE, C.G. TO REF.}} \\
 & + \underbrace{\left[ \frac{T_1 - T_4}{m} \right] \left( \frac{y_1}{b} \right) \left( \frac{1}{b \bar{c}} \right) + \left[ \frac{T_2 - T_3}{m} \right] \left( \frac{y_2}{b} \right) \left( \frac{1}{b \bar{c}} \right)}_{\text{UNSYMMETRICAL THRUST}} \\
 & + \underbrace{\left( \frac{K_b n \lambda}{m} \right) \left( \frac{1}{b} \right) \left( \frac{1}{b \bar{c}} \right) + K_d (B P_R - B P_L) \left( g + \frac{\lambda}{m} \right) \left( \frac{G'}{4 c} \right) \left( \frac{c}{b} \right) \left( \frac{1}{b \bar{c}} \right)}_{\text{PROPELLER} \rightarrow \text{GROUND BRAKING}}
 \end{aligned}$$

$$\begin{aligned}
 (21) \frac{L}{I_X} = & \left[ C_l + C_{l_p} \left( \frac{p b}{V} \right) + C_{l_r} \left( \frac{r b}{V} \right) \right] \left( \frac{e v^2}{2} \right) \left( \frac{s}{m} \right) \left( \frac{1}{b \bar{a}} \right) \\
 & + \underbrace{\left[ \frac{D}{c} \times \frac{Y'}{m} + \frac{G}{c} \times \frac{Z'}{m} \right] \left( \frac{c}{b} \right) \left( \frac{1}{b \bar{a}} \right)}_{\text{DISTANCE, C.G. TO REF.}}
 \end{aligned}$$

\* EFFECT OF ENGINE THRUST DURING TAKE-OFF

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HINGE MOMENT EQUATIONS

$$(22) \quad H_E = \left[ K_{HE} + K_{HEq} \left( \frac{qc}{V} \right) + K_{HE\dot{\alpha}} \left( \frac{\dot{\alpha}c}{V} \right) \right] \left( \frac{eV^2}{2} \right) + f_d(T, V, \delta E)$$

$$(23) \quad H_R = \left[ K_{HR} + K_{HR\lambda} \left( \frac{\lambda b}{V} \right) \right] \left( \frac{eV^2}{2} \right) + f_e(T, V, \delta R)$$

$$(24) \quad H_{AL} = \left[ K_{HAL} + K_{HALp} \left( \frac{pb}{V} \right) \right] \left( \frac{eV^2}{2} \right)$$

$$(25) \quad H_{AR} = \left[ K_{HAR} + K_{HARp} \left( \frac{pb}{V} \right) \right] \left( \frac{eV^2}{2} \right)$$

AUXILIARY EQUATIONS

$$(26) \quad C_L = f_1(\alpha, \delta F, \sum T'_c) \times f_2(\delta) + f_3(\delta E)(1 + K_1 \sum T'_c) + f_4(\alpha, m_n)$$

+ M<sub>1</sub> - STALL TERM

$$(27) \quad C_D = f_5(\alpha, \delta F) + f_6(\delta) + f_7(\delta R, \delta) + f_8(\delta E, \alpha)$$

$$+ K_2 C_{f_1} + K_3 C_{f_2} + K_4 C_{f_3} + K_5 C_{f_4} + K_6 L_G$$

┌────────── COWL FLAPS ─────────┐ ┌ LANDING GEAR ─┐

$$+ K_7 B_D + f_9(\alpha, m_n) + M_2$$

┌ BOMB DOORS ─┐

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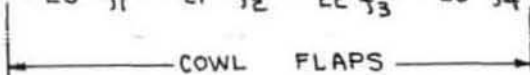
$$(28) C_F = f_{10}(\delta, T'_{C_{2+3}}) + K_8 T'_2 + K_9 T'_3 + K_{10} \delta \alpha + K_{11} \delta \delta F$$

$$+ f_{11}(\delta R)(1 + K_{12} T'_2 + K_{13} T'_3) + M_3 + M_4 \delta + M_5 \delta R$$

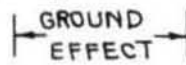
$$(29) C_m = f_{12}(\alpha, \delta E, \delta F, T'_{C_{2+3}}) + f_{13}(\alpha, [T'_2 - T'_3]) + K_{15} T'_1$$

$$+ K_{16} T'_4 + f_{14}(\delta, \alpha) + f_{15}(\delta R, \delta) + K_{17} \delta E_t + K_{18} \delta A_L$$

$$+ K_{19} \delta A_R + K_{20} C_{f1} + K_{21} C_{f2} + K_{22} C_{f3} + K_{23} C_{f4}$$



$$+ K_{24} L_G + (K_{25} + K_{25.1} \alpha) B_D + f_{16}(\alpha, m_n) + f_{17}(h) \times \alpha$$

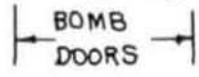


$$+ M_6 + M_7 \alpha + M_8 \delta E$$

$$(30) C_n = f_{18}(\delta, \delta F, \alpha) + f_{19}(\delta, \delta R, T'_{C_{2+3}}) + f_{19.1}(T'_2 - T'_3)$$

$$+ f_{20}(\delta A_L, \alpha) + f_{21}(\delta A_R, \alpha) + K_{26.9}(\delta R_t)$$

$$+ K_{27} \delta B_D + M_9 + M_{10} \delta + M_{11} \delta R \pm \text{STALL TERM}$$



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$$(31) C_L = f_{23}(\gamma, \alpha, \delta F) + \left[ f_{24}(\alpha, \delta A_L) + f_{25}(\alpha, \delta A_R) \right] \left( 1 - \frac{\gamma}{V_d} \right)^{K_{27.1}}$$

$$+ f_{26}(\delta R) + (K_{28} + K_{29} \gamma) T'_{C1} + (K_{30} + K_{31} \gamma) T'_{C2}$$

$$+ (K_{32} + K_{33} \gamma) T'_{C3} + (K_{34} + K_{35} \gamma) T'_{C4} + K_{36} \delta A_{Lt}$$

$$+ K_{37} \delta A_{Rt} + M_{12} + M_{13} \gamma + M_{14} \delta R$$

$$(32) C_{mq} = f_{27} (T'_{C2+3})$$

$$(33) C_{m\alpha} = f_{28} (T'_{C2+3})$$

$$(34) C_{n_L} = f_{29}(\alpha, \delta F) + K_{38}(T'_{C1} + T'_{C4}) + K_{38.1}(T'_{C2} + T'_{C3})$$

$$(35) C_{np} = f_{30}(\alpha, \delta F)$$

$$(36) C_{lp} = f_{32}(\alpha, \delta F)$$

$$(37) C_{l_L} = f_{34}(\alpha, \delta F)$$

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$$(38) \quad C_{m_t} = K_{39.1} + K_{39.2} \delta F + K_{39.3} \delta E + [K_{39.4} + K_{39.5} T'_{C_{2+3}}] \alpha$$

$$(39) \quad C_{n_t} = [K_{39.6} + K_{39.7} T'_{C_{2+3}}] \delta + [K_{39.8} + K_{39.9} T'_{C_{2+3}}] \delta R$$

$$(40) \quad K_{HE} = f_{38}(\alpha, \delta F, \delta E, T'_{C_2}, T'_{C_3}) + f_{39}(\delta E_t, \delta E, T'_{C_{2+3}}) \\ + M_{15} \alpha + M_{16} \delta E$$

$$(41) \quad K_{HEq} = f_{40}(T'_{C_2}, T'_{C_3})$$

$$(42) \quad K_{HE\alpha} = f_{41}(T'_{C_2}, T'_{C_3})$$

$$(43) \quad K_{HR} = f_{42}(\delta, \delta R, T'_{C_2}, T'_{C_3}) + f_{43}(\delta R_t, \delta R, T'_{C_{2+3}}) f_{44}(\delta) \\ + f_{45}(\delta, \alpha, \delta F) + M_{17} \delta + M_{18} \delta R.$$

$$(44) \quad K_{HR\alpha} = f_{46}(T'_{C_{2+3}})$$

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$$(45) \quad K_{HAL} = f_{47}(\delta A_L, \alpha, \delta F) + f_{48}(\delta A_L, \delta) + f_{49}(\alpha, \delta)$$

$$+ f_{50}(\delta A_{Lt}) + M_{19} \alpha + M_{20} \delta A_L$$

$$(46) \quad K_{HAR} = f_{51}(\delta A_R, \alpha, \delta F) + f_{52}(\delta A_R, \delta) + f_{53}(\alpha, \delta)$$

$$+ f_{54}(\delta A_{Rt}) + M_{21} \alpha + M_{22} \delta A_R$$

$$(47) \quad K_{HALP} = K_{43}$$

$$(48) \quad K_{HARP} = K_{44}$$

## INSTRUMENT EQUATIONS

$$(49) \quad \text{AIR SPEED METER READING, } V_c = f_{55}(\text{I.A.S., } h)$$

$$(50) \quad \text{RATE OF CLIMB, } R.C. = \mu \sin \theta - \nu \cos \theta \sin \varphi - \mu \cos \theta \cos \varphi$$

$$(51) \quad \text{ALTIMETER, } h = \int_0^t (R.C.) dt$$

$$(52) \quad \text{PITCH BAR OF GYRO HORIZON} = \theta$$

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$$(53) \text{ BANK ANGLE OF GYRO HORIZON} = \sin^{-1}(\cos \theta \sin \varphi)$$

$$(54) \text{ RATE OF TURN} = \omega$$

$$(55) \text{ BALL BANK ANGLE, } \mu' = \tan^{-1} \frac{a_y}{a_z}$$

$$(56) \text{ COMPASS HEADING} = \psi$$

ENGINE EQUATIONS-FOR ONE INTERNAL COMBUSTION RECIPROCATING ENGINE

$$(57) Q = K_{45} N e_i$$

$$(58) P_2 = f_{56}(P_1, N)$$

$$(59) \Delta P_c = f_{57}(Q, \pi)$$

$$(60) \text{ CHOOSE } Q \text{ IN } \Delta P_c = f_{57}(Q, \pi) \text{ SO THAT } \frac{P_2 + \Delta P_c}{P_2} \leq .53$$

$$(61) P_3 = P_2 + \Delta P_c$$

$$(62) \frac{P_4}{P_3} = f_{58}(N, \text{BLOWER POSITION})$$

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$$(63) \quad P_4 = MP = P_3 \left( \frac{P_4}{P_3} \right)$$

$$(64) \quad C_i = K_{46} MP$$

$$(65) \quad R = f_{59} (MP, N)$$

$$(66) \quad IHP = K_{47} Q R$$

$$(67) \quad FHP = f_{60} (N)$$

$$(68) \quad y_{d1} = f_{60.1} \left( \frac{P_2}{P_1} \right)$$

$$(69) \quad y_{d2} = f_{60.2} \left( \frac{P_4}{P_3} \right)$$

$$(70) \quad SHP_A = K_{48} Q y_{d1}$$

$$(71) \quad SHP_M = K_{48} Q y_{d2}$$

$$(72) \quad \Delta HP = f_{61} (h)$$

$$(73) \quad BHP = IHP - FHP - SHP_A - SHP_M + \Delta HP$$

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$$(74) \quad PHP = K_{50} C_P e n^3$$

$$(75) \quad C_P = f_{62}(\beta, J)$$

$$(76) \quad J = K_{51} \frac{V}{n}$$

$$(77) \quad PHP = BHP$$

$$(78) \quad C_T = f_{63}(\beta, J)$$

$$(79) \quad T_i = K_{52} C_T \rho n^2$$

## MISCELLANEOUS EQUATIONS

$$(80) \quad m_n = \frac{V}{V_S}$$

$$(81) \quad V_S = f_{64}(h)$$

$$(82) \quad e = f_{65}(h)$$

$$(82a) \quad e/e_0 = f_{65.1}(h) = \sigma$$

$$(83) \quad P_i = f_{66}(h)$$

$$(82b) \quad I.A.S. = V \sqrt{\frac{e}{e_0}} = V \sqrt{\sigma}$$

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$$(84) \quad T_{c1}' = \frac{T_1}{\frac{1}{2} e v^2 S}$$

$$(85) \quad T_{c2}' = \frac{T_2}{\frac{1}{2} e v^2 S}$$

$$(86) \quad T_{c3}' = \frac{T_3}{\frac{1}{2} e v^2 S}$$

$$(87) \quad T_{c4}' = \frac{T_4}{\frac{1}{2} e v^2 S}$$

$$(88) \quad T_c' = T_{c1}' + T_{c2}' + T_{c3}' + T_{c4}'$$

$$(89) \quad T_{c2+3}' = T_{c2}' + T_{c3}'$$

$$(90) \quad T = T_1 + T_2 + T_3 + T_4$$

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TABLE OF SYMBOLSSymbols for Equations of MotionAXES

- 1) Earth Axes
  - A - North
  - B - East
  - C - Down toward center of earth
- 2) Body Axes - Origin at airplane Center of Gravity
  - X - forward along thrust line
  - Y - Along right wing
  - Z - down perpendicular to XOY
- 3) Wind Axes - Origin at airplane Center of Gravity
  - $\xi$  - forward along relative wind (instantaneous flight path)
  - $\eta$  - toward right wing perpendicular to  $O\xi$
  - $\zeta$  - down perpendicular to  $\xi O\eta$

FORCES

- 1) Along Earth Axes
  - W - weight of airplane along OC
- 2) Along Body Axes
  - X' - along OX
  - Y' - along OY
  - Z' - along OZ
- 3) Along Wind Axes
  - $\Delta$  - along  $O\xi$  in the negative drag direction
  - F - along  $O\eta$  in the positive side force direction
  - $\lambda$  - along  $O\xi$  in the negative lift direction

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MOMENTS Ft. Pounds

## 1) About Body Axes

- $L$  - Rolling moment about  $OX$   
 $M$  - Pitching moment about  $OY$   
 $N$  - Yawing moment about  $OZ$

LINEAR VELOCITIES Feet per Second

## 1) Along Wind Axes

$V$  - resultant velocity along  $O\xi$

The velocities along  $O\xi$  and  $O\eta$  are zero.

## 2) Along Body Axes

- $u$  - velocity along  $OX$   
 $v$  - velocity along  $OY$   
 $w$  - velocity along  $OZ$

ANGULAR VELOCITIES Radians per Second

## 1) About Earth Axes

$\frac{d\phi}{dt}$  - about  $OX$

$\frac{d\theta}{dt}$  - about line in intersection of plane  $AOB$  and  $YOZ$

$\frac{d\psi}{dt}$  - about  $OC$

## 2) About Body Axes

- $p$  - about  $OX$   
 $q$  - about  $OY$   
 $r$  - about  $OZ$

3) About Wind Axes  $\dot{\alpha}$  about  $O\eta$ ACCELERATIONS Ft. per Second per Second1) Along Earth Axes -  $g$  - gravity along  $OC$ 

## 2) Along Body Axes

- $a_x$  - along  $OX$   
 $a_y$  - along  $OY$   
 $a_z$  - along  $OZ$

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MOMENTS OF INERTIA Pound - Feet - Second<sup>2</sup>

1) About Body Axes

$$\begin{aligned} I_x & - \text{about } OX = \bar{a}mb^2 \\ I_y & - \text{about } OY = \bar{b}mb^2 \\ I_z & - \text{about } OZ = \bar{c}mb^2 \end{aligned}$$

ANGLES Degrees

$$\begin{aligned} \theta & - \text{angle between } OX \text{ and plane } AOB \text{ in plane } XOC \\ \psi & - \text{angle between } OA \text{ and plane } XOC \text{ in plane } AOB \\ \phi & - \text{angle between } OY \text{ and plane } AOB \text{ in plane } YOZ \\ \alpha & - \text{angle between } OX \text{ and plane } \xi O\eta \text{ in plane } XOZ \\ \delta & - \text{angle between } O\xi \text{ and plane } XOZ \text{ in plane } \xi O\eta \end{aligned}$$

TIME

$$t \quad - \text{seconds}$$

SYMBOLS FOR AUXILIARY EQUATIONS

$$\begin{aligned} C_L & - \text{lift coefficient - static} \\ C_D & - \text{drag coefficient - static} \\ C_F & - \text{side force coefficient - static} \\ C_m & - \text{pitching moment coefficient - static} \\ C_n & - \text{yawing moment coefficient - static} \\ C_\ell & - \text{rolling moment coefficient - static} \\ C_{mq} & - \text{pitching moment coefficient due to pitching velocity: } \left(\frac{v}{c}\right)\left(\frac{\delta C_m}{\delta q}\right) \\ C_{m\dot{\alpha}} & - \text{pitching moment coefficient due to rate of change of} \\ & \quad \text{angle of attack } \left(\frac{v}{c}\right)\left(\frac{\delta C_m}{\delta \dot{\alpha}}\right) \\ C_{n\dot{\chi}} & - \text{yawing moment coefficient due to yawing velocity: } \left(\frac{v}{b}\right)\left(\frac{\delta C_n}{\delta \dot{\chi}}\right) \\ C_{n\dot{p}} & - \text{yawing moment coefficient due to rolling velocity: } \left(\frac{v}{b}\right)\left(\frac{\delta C_n}{\delta \dot{p}}\right) \\ C_{\ell\dot{p}} & - \text{rolling moment coefficient due to rolling velocity: } \left(\frac{v}{b}\right)\left(\frac{\delta C_\ell}{\delta \dot{p}}\right) \\ C_{\ell\dot{\chi}} & - \text{rolling moment coefficient due to yawing velocity: } \left(\frac{v}{b}\right)\left(\frac{\delta C_\ell}{\delta \dot{\chi}}\right) \\ F_S & - \text{stick or column force - pounds} \\ F_R & - \text{rudder pedal force - pounds} \\ F_W & - \text{aileron wheel force - pounds} \\ H_E & - \text{elevator hinge moment - ft. lbs.} \\ H_R & - \text{rudder hinge moment - ft. lbs.} \end{aligned}$$

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- $H_{AL}$  - left aileron hinge moment - ft. lbs.
- $H_{AR}$  - right aileron hinge moment - ft. lbs.
- $K_{HE}$  - elevator hinge moment modulus - ft.<sup>3</sup>
- $K_{HR}$  - rudder hinge moment modulus - ft.<sup>3</sup>
- $K_{HAL}$  - left aileron hinge moment modulus - ft.<sup>3</sup>
- $K_{HAR}$  - right aileron hinge moment modulus - ft.<sup>3</sup>
- $K_{HEq}$  - elevator hinge moment modulus due to pitching velocity:  $(\frac{V}{c})(\frac{\delta K_{HE}}{\delta q})$
- $K_{HE\dot{\alpha}}$  - elevator hinge moment modulus due to rate of change of angle of attack:  $(\frac{V}{c})(\frac{\delta K_{HE}}{\delta \dot{\alpha}})$
- $K_{HR\dot{\chi}}$  - rudder hinge moment modulus due to yawing velocity:  $(\frac{V}{b})(\frac{\delta K_{HR}}{\delta \dot{\chi}})$
- $K_{HALp}$  - left aileron hinge moment modulus due to rolling velocity:  $(\frac{V}{b})(\frac{\delta K_{HAL}}{\delta p})$
- $K_{HARp}$  - right aileron hinge moment modulus due to rolling velocity:  $(\frac{V}{b})(\frac{\delta K_{HAR}}{\delta p})$
- $C_{mt}$  - pitching moment coefficient contributed by horizontal tail
- $C_{nt}$  - yawing moment coefficient contributed by vertical tail
- $\theta_0$  - angle between OX and ground with plane at rest
- $\delta E$  - elevator angle
- $\delta R$  - rudder angle
- $\delta A$  - total aileron angle =  $\delta A_L + \delta A_R$
- $\delta A_L$  - left aileron angle
- $\delta A_R$  - right aileron angle
- $\delta E_t$  - elevator tab angle
- $\delta R_t$  - rudder tab angle
- $\delta A_{Lt}$  - left aileron tab angle
- $\delta A_{Rt}$  - right aileron tab
- $\delta F$  - flap angle
- $T_1$  - thrust delivered by port outboard engine - pounds
- $T_2$  - thrust delivered by port inboard engine - pounds
- $T_3$  - thrust delivered by starboard inboard engine - pounds
- $T_4$  - thrust delivered by starboard outboard engine - pounds

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- $T$  - total thrust (four engines) - pounds
- $T_j$  - constant thrust from jato installation operative for a specified length of time
- $T_c'$  - total thrust coefficient (four engines)
- $T_{c2+3}'$  - total thrust coefficient (port and starboard inboard engines)
- $T_{c1}'$  - thrust coefficient (port outboard engine)
- $T_{c2}'$  - thrust coefficient (port inboard engine)
- $T_{c3}'$  - thrust coefficient (starboard inboard engine)
- $T_{c4}'$  - thrust coefficient (starboard outboard engine)
- $L_G$  - % landing gear deflection
- $B_D$  - % bomb door deflection
- $C_{f1}$  - % cowl flap deflection port outboard engine
- $C_{f2}$  - % cowl flap deflection port inboard engine
- $C_{f3}$  - % cowl flap deflection starboard inboard engine
- $C_{f4}$  - % cowl flap deflection starboard outboard engine
- $B_{FL}$  - % brake pressure - left brake
- $B_{FR}$  - % brake pressure - right brake
- $m$  - airplane mass - slugs
- $s$  - wing area - sq. ft.
- $b$  - span - ft.
- $c$  - mean aerodynamic chord - ft.
- $y_1$  - distance to outboard motor  $Q$  along  $OY$  - feet
- $y_2$  - distance to inboard motor  $Q$  along  $OY$  - feet
- c.g. - center of gravity
- $D$  - distance of c.g. below reference point along  $OZ$  - feet
- $D'$  - distance below reference point to point of contact of main wheels and ground along  $OZ$  - feet
- $G$  - distance of c.g. to right of reference point along  $OY$  - feet
- $G'$  - main wheel tread - feet
- $H$  - distance of c.g. ahead of reference point along  $OX$  - feet
- $H'$  - distance forward of reference point to point of contact of main wheels and ground along  $OX$  - feet

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- $\bar{a}$  - moment of inertia coefficient -  $OX$  axis
- $\bar{b}$  - moment of inertia coefficient -  $OY$  axis
- $\bar{c}$  - moment of inertia coefficient -  $OZ$  axis
- $\rho_0$  - air density (standard sea level) - pound-sec<sup>2</sup> per ft.<sup>4</sup>
- $\rho$  - air density (standard at altitude) - pound-sec<sup>2</sup> per ft.<sup>4</sup>
- $\sigma$  - density ratio
- $h$  - altitude - ft.
- $V_s$  - velocity of sound - ft/sec
- $V_d$  - aileron divergence speed - ft/sec
- $m_n$  - mach number
- $\mu$  - coefficient of ground friction
- $\mu'$  - ball bank angle - degrees
- $R_N$  - correction factor to pitching moment due to airplane structural deflection
- $R_M$  - correction factor to yawing moment due to airplane structural deflection
- $f( )$  - designates a function of the variable in ( ). In general represented by a curve or family of curves.
- $K_1$  etc. - aerodynamic constants
- $M_1$  etc. - manual setting constants

SYMBOLS FOR ENGINE EQUATIONS

- $A$  - displacement of engine - cubic inches
- $N$  - engine revolutions per minute
- $n$  - engine revolutions per second
- $Q$  - mass air flow through engine - pounds per hour
- $M$  - mass air flow through engine - pounds per second
- $\pi$  - throttle angle - degrees
- $\rho_i$  - inlet density (density at cylinder inlet) pounds - sec<sup>2</sup> per ft.<sup>4</sup>
- $MP$  - manifold pressure - inches of mercury absolute
- $P_c$  - pressure drop through carburetor - inches of mercury absolute
- $P_1$  - atmosphere pressure - pressure at inlet of auxiliary stage - inches  $H_g$  absolute
- $P_2$  - pressure at exit of auxiliary stage - in  $H_g$  absolute

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- $P_3$  - pressure at exit of carburetor - pressure at inlet to main stage of supercharger - inches  $H_g$  absolute  
 $P_4$  - pressure at exit of main stage of supercharger = MP  
 $R$  - correction factor to IHP  
IHP - indicated horsepower  
FHP - friction horsepower  
 $SHP_M$  - supercharger horsepower for main stage  
 $SHP_A$  - supercharger horsepower for auxiliary stage  
 $\Delta HP$  - horsepower increase due to decreased back pressure  
~~BHP~~ - ~~brake horsepower~~  
PHP - propeller horsepower  
G.R. - gear ratio  
 $D_p$  - propeller diameter feet  
 $J$  - advance diameter ratio  
 $C_p$  - propeller power coefficient  
 $C_t$  - propeller thrust coefficient  
 $\beta$  - propeller blade angle - degrees  
 $\gamma_{a_1}$  - adiabatic factor for auxiliary stage  
 $\gamma_{a_2}$  - adiabatic factor for main stage  
 $K_{48}$  - constant  $\frac{j C_p t_1}{550 \eta_1}$   
 $j$  - mechanical equivalent of heat  
 $t_1$  - inlet temperatures to both auxiliary and main stages of superchargers - assumed to be constant - absolute  $520^\circ F.$   
 $C_p$  - specific heat of air at constant pressure

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- $\eta_1$  - supercharger efficiency assumed to be constant
- $G_s$  - governor setting

Compiled by: \_\_\_\_\_

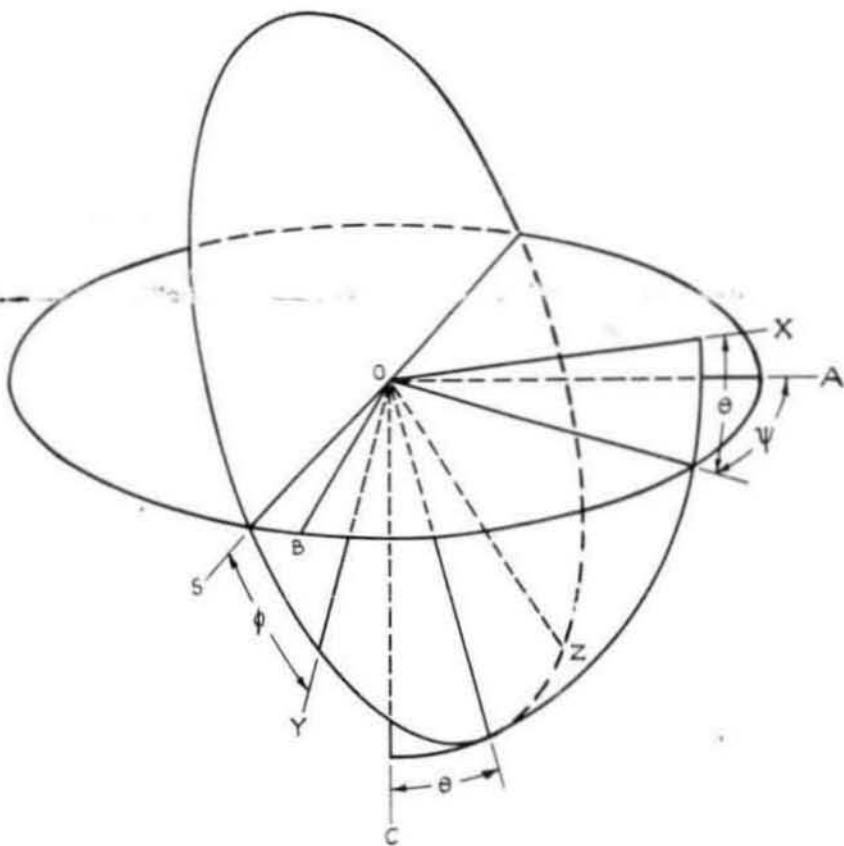
Approved: \_\_\_\_\_

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A, B, C are earth axes,  
OA toward north.

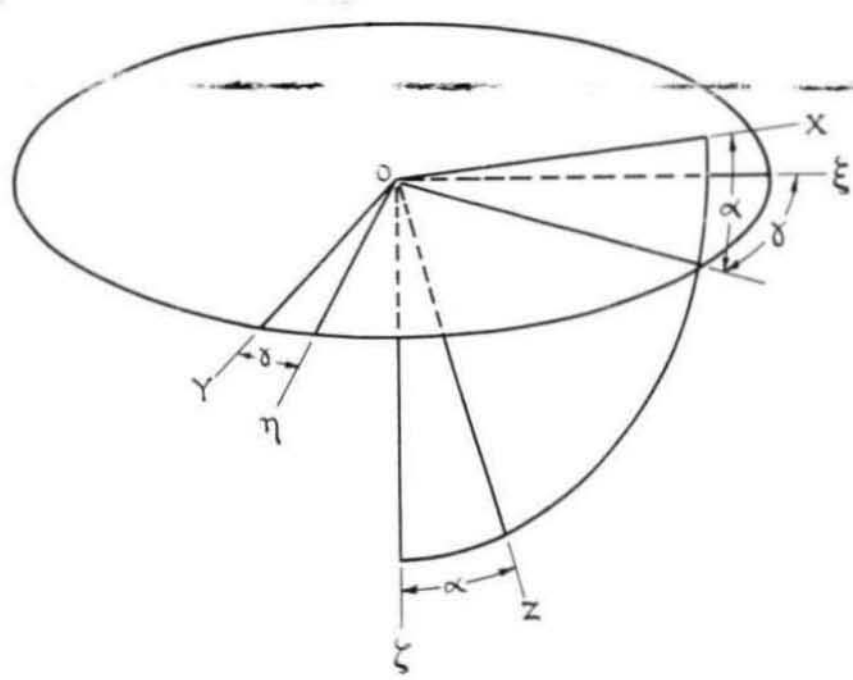
X, Y, Z are body axes,  
OX toward airplane nose.

FIG. 1 - Sketch of Earth and Body Axes

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$\xi, \eta, \zeta$  are wind axes

X, Y, Z, are body axes

FIG. 2

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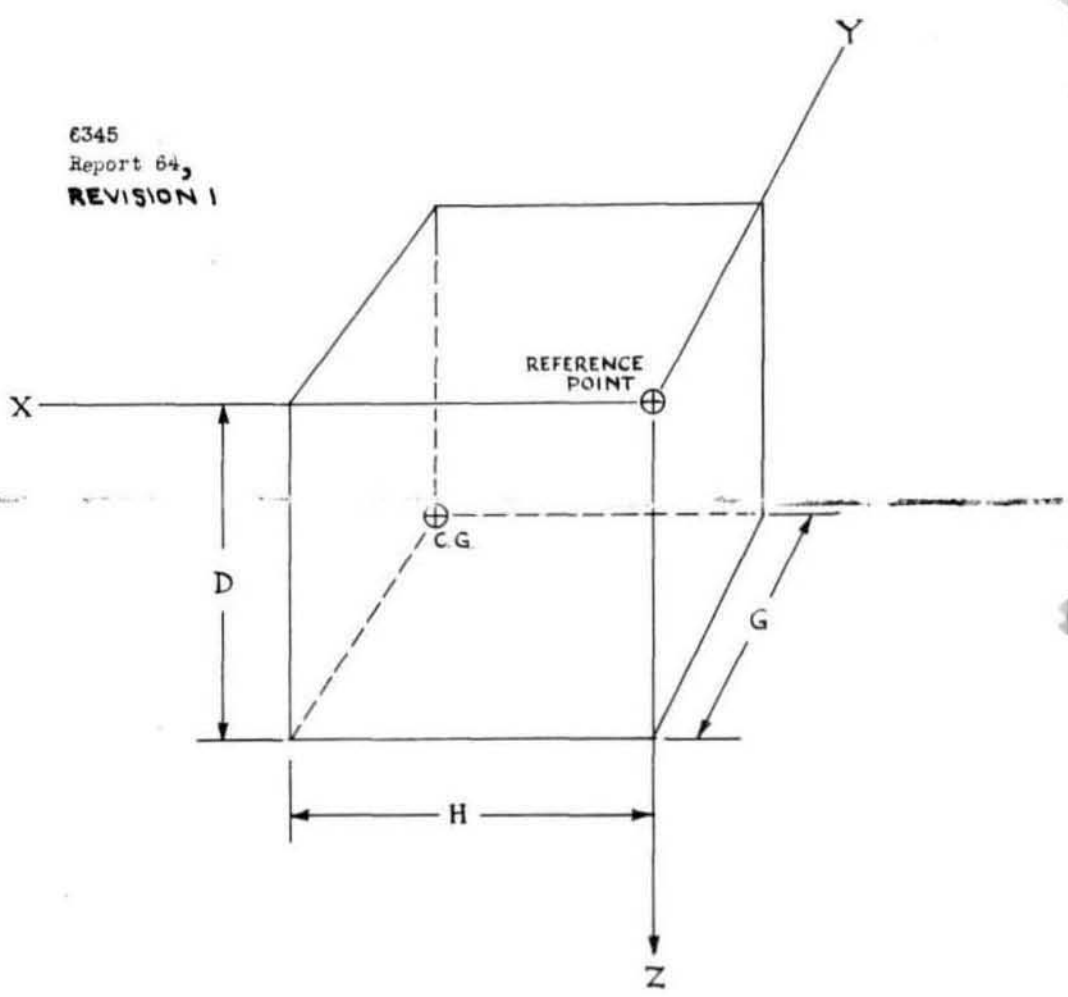


FIG. 3 - Sketch of C. G. Location

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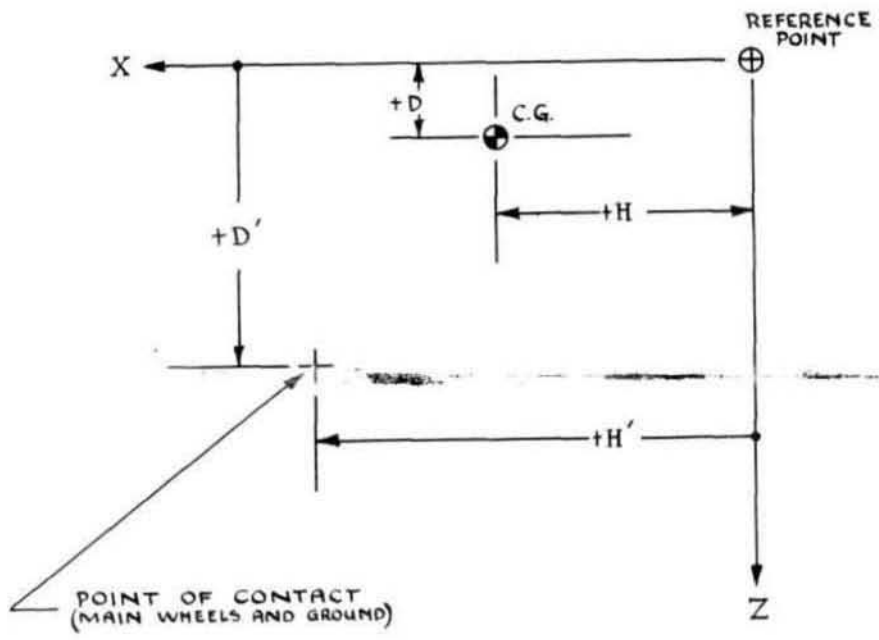


FIG. 4 - Location of Point of Contact  
Between Main Wheels and Ground

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## APPENDIX B

to

PROJECT  
WHIRLWIND  
(DEVICE RF-12)

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NON-LINEAR COEFFICIENT EXAMPLES

The following non-linear coefficients are typical examples of the different types of input data. These examples were chosen as illustrations of the variety of slopes, magnitudes and inflexion points encountered in wind tunnel data.

The largest term in the expression for lift coefficient,  $f_1(\alpha, \delta F, T_c^i)$  is shown on drawing B-38000-G for  $T_c^i = 0$ . The curves for different flap angles,  $\delta F$ , are approximately parallel and straight up to the stall point. At the stall point the curves are not very critical for computations in the analyzer since the stall condition will be handled empirically and the curves will be modified at this point.

$f_4(\alpha, m_n)$ , drawing A-38005-G, shows curves which cross each other. It will be noted that the cross-overs occur at high mach numbers (above 0.5) corresponding to high airplane speeds. This contribution to the lift coefficient is limited to low angles of attack since it is impossible to fly at high angles of attack and high speeds.

$f_7(\delta R, Y)$ , drawing B-38008-G, illustrates a smoothly varying function whose curves cross at the origin. This contribution to the total drag coefficient is small or negligible in normal flight but may become as much as 50% immediately after an outboard engine failure.

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$f_{13}(\alpha, T_{c_2}' - T_{c_3}')$ , drawing A-38046-G, is a function which is difficult to represent as an analytical function and, if represented by a function table, presents difficulty in interpolation in the region near the origin.

$f_{19}(\delta, \delta R, T_{c_2+3}')$ , drawing A-38053-G, is typical of a family of curves considerably different from the other curves discussed.

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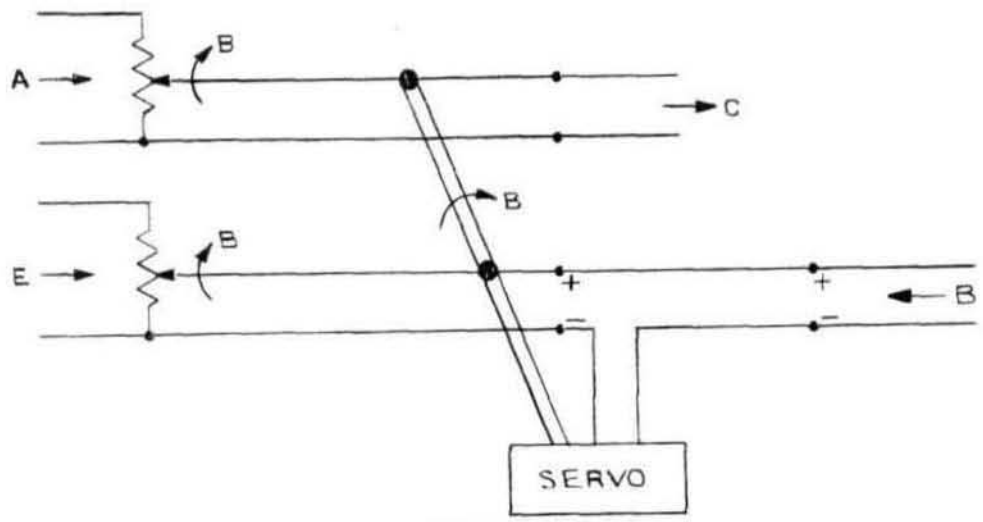
## APPENDIX C

to

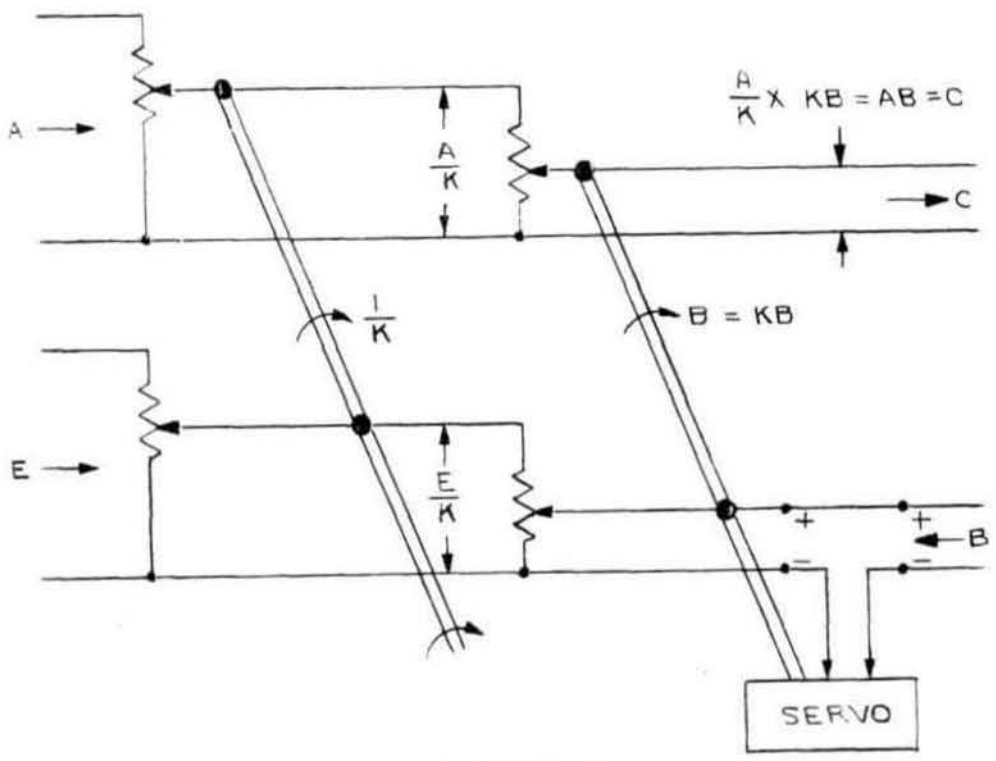
PROJECT  
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(DEVICE RF-12)SUMMARY REPORT NO. 1  
April 1946TWO-STAGE POTENTIOMETER MULTIPLIER

A single-stage potentiometer multiplier is shown on Sketch 1 of the following page. Input A is supplied as an electrical voltage and input B is converted to shaft rotation by means of the servo system using a feedback potentiometer supplied with constant voltage E. The product, C, is obtained as a voltage output. For a given voltage input A, an error in C is introduced by inaccuracies in the resistance element, by back-lash or looseness in the control shaft and contact assembly and by lack of sensitivity arising from a finite number of increments in the resistance element and from the dead zone in the servo system. Since errors due to these sources are approximately constant, that is, independent of shaft angle B, while the output voltage is proportional to B, fractional errors in the output are approximately inversely proportional to B. This limitation becomes serious when one attempts to cover a wide dynamic signal range.

The two-stage multiplier extends the useful range of sensitivity by using two potentiometers in cascade. Such a system is illustrated in the second sketch. The first potentiometer slider is driven through the scale factor angle  $1/K$  while the second set of potentiometers perform the multiplication  $(B')(1/K)$ . Because of the corresponding connection of the servo feedback potentiometers, angle  $B'$  equals the scale factor  $K$  times  $B$ .



SKETCH 1



SKETCH 2

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In operation, shaft positions  $1/K$  will be adjusted to maintain shaft position  $B'$  well above the level of minimum sensitivity and noise. Shaft position  $1/K$  can be adjusted at the beginning of a particular computation to provide the proper scale factor for the following series of computations. However, as was planned for this analyzer, the shaft position  $1/K$  can be continuously adjusted by a servo system loosely coupled to shaft position  $B'$ . Such coupling system must be made through potentiometers, tachometers, and limit stops to properly coordinate the operation of the two potentiometer sets.

The objective of the cascaded two-stage multiplier is primarily to increase the range of sensitivity rather than to improve accuracy.

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APPENDIX D  
to  
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FREQUENCY-MODULATED SERVO

An electro-mechanical computer requires numerous servos to drive its mechanical elements. For a real-time aircraft analyzer analogy computer, the requirements for these servos would be particularly severe.

Wherever forces and accelerations are converted from electrical signals to the mechanical positions of integrator carriages or multiplier potentiometers, servos must be used which are capable of following the rapid fluctuations possible in these variables.

The approximate specifications for the type of computing elements being considered are:

1. Peak power outputs of about 100 watts
2. Low standby losses
3. Very high static accuracy including high stiffness
4. Extremely good transient response including high maximum accelerations
5. 400 cps data

A short survey of readily available servo types discovered none that showed promise of meeting these requirements. Instead, a new type of servo was developed utilizing the desirable characteristics of a frequency controlled low slip induction motor. A block schematic of this system is shown in Drawing B-30010. A frequency controlled poly-phase induction motor is desirable for the following reasons:

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1. High torque-slip ratio leads to good transient response and high accelerations and stiffness at all operating speeds.
2. Standby heating is low because rotor losses are zero at standstill. High peak power outputs over short time intervals are thus available with small motors and low continuous heat-dissipating capacity.

Supplying such a motor with varying frequencies requires considerable equipment. These frequencies must vary from a maximum in one phase rotation to a maximum in the opposite phase rotation through all frequencies in between, including zero. All circuits carrying motor power must, therefore, be able to handle direct current as well as alternating currents up to perhaps 60 cps.

This requirement is met by using a beat-frequency oscillator, the variable frequency unit of which is adjustable both above and below the frequency of the fixed frequency oscillator. The fixed frequency oscillator produces 3-phase voltages at oscillator frequency. These are beat against the single-phase variable frequency resulting in 3-phase difference frequencies.

The servo error signal is detected and the resulting d-c supplied to the grid of a reactance tube across the plate load of the variable frequency oscillator. An oscillator output frequency proportional to servo error is thus obtained.

The 3-phase difference frequencies are supplied to the thyatron power stages which supply the motor. The 3 power stages each consist of a pair of gas triodes with a-c plate voltage supplied through transformers. Which tube is to fire and over how much of a plate-voltage cycle is determined by the phase and magnitude of the oscillator output voltage supplied. The phase and magnitude of the voltage supplied to the motor winding is thus determined by the oscillator output, and the motor is supplied with 3-phase voltages of the required frequency.

The motor itself can be any polyphase induction motor but one especially designed for low inertia and low slip will provide better performance.

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An experimental servo of this type was built in a 50-watt size. It proved very satisfactory. With proper adjustment it was found possible to obtain transient decay times of the order of .01 seconds with loads comparable to integrator drives. Static errors were within the errors of the data system and static stiffness was adequate. Measured dynamic and steady state characteristics were in good agreement with expected performance.

The frequency modulated servo would be able to satisfy the more stringent servo requirements for the analogy computer. Considerable electronic equipment is needed for each servo but the amount is not excessive in view of the freedom from weight and space requirements in a computer of this type. The amount of equipment is also largely independent of servo rating; changing the size of the servo motor requires changing only the size of power stage thyratrons and transformers.

Further information as to the characteristics of the frequency-modulated servo may be found in 6345 Reports 74 through 83 listed in Appendix E.

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## APPENDIX E

to

PROJECT  
WHIRLWIND  
(DEVICE RF-12)SUMMARY REPORT NO. 1  
April 1946

Below is a list of titles and brief descriptions of some reports which have been written during the progress of work on Contracts NOa(s)5216 and NOa(s)7082. Missing numbers in the series belong to reports which are obsolete or have been withdrawn from circulation.

<u>Report No.</u>	<u>Date</u>	
4	Jan. 16, 1945	Two-Phase Induction Motors  A study of the Diehl FFF-49-5 squirrel cage two-phase induction motor as a torque motor for use in the control force loading equipment.
5	Jan. 20, 1945	Phase-Sensitive Detector  A bridge-type diode phase-sensitive detector for use in converting a-c to d-c signals.
6	Jan. 7, 1945	Throttle Valve  Preliminary tests of the first model designed for use in the control force loading equipment.
7	Jan. 17, 1945	Viscosity vs. Leakage  Studies of a Variable Displacement Hydraulic Pump.
10	Jan. 17, 1945	Preliminary Estimates of Numerical Value Ranges  For aircraft that are to be handled by the Stability Control Analyzer.

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<u>Report No.</u>	<u>Date</u>	
12	Jan. 22, 1945	Lift Coefficients  Data on the nature of lift coefficients.
13	Jan. 26, 1945	Strain Gauges for Control Force Measurement  Data on the Ruge-deForest Type wire strain gauge for use in control force loading equipment.
14	Jan. 30, 1945	Simulation of a Function of Several Variables  This is a report written and issued originally by the Bell Telephone Laboratories.
18	Feb. 6, 1945	Aircraft Oscillations  A listing of the kinds of oscillations with natural period and damping to be expected in large aircraft.
19	Feb. 7, 1945	60-Cycle Modulator Circuit  An electronic modulator circuit for converting d-c to 60-cycle a-c signals.
21	Apr. 13, 1945	Control Transformers  A report on laboratory tests of standard Navy control transformers.
22	Feb. 22, 1945	Preliminary Investigation of Summing Circuits  For adding and subtracting 60-cycle a-c voltages.
23	Feb. 27, 1945	Precision Potentiometers  Information on the Western Electric light-weight precision potentiometer.
24	Feb. 28, 1945	Lift, Drag, and Side Force Coefficients  For use in the aircraft equations of motion.
26	Apr. 19, 1945	Parallel-T Networks  Experimental studies of parallel-T networks for use as servo derivative networks where a 60-cycle carrier is used.

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Report No.	Date	
28	Feb. 1, 1945	Resolver - Voltage Output and Phase Shift The voltage output and phase shift of Arma Corporation electrical resolver.
29	Mar. 23, 1945	Summing Amplifiers, Electronic Second report.
30	Mar. 26, 1945	Potentiometers General comments.
33	Mar. 26, 1945	Tachometers Experimental tests of Arma and Kollman a-c tachometers.
35	Mar. 23, 1945	Preliminary Tests of an Electro-Mechanical Inte- grator.
36	May 3, 1945	Description of Proposed Control Force Demonstrator
37	Apr. 28, 1945	Control Column Loading Equipment, Analysis of Component Parts
38	May 4, 1945	Control Column Loading Equipment, Stability and Gain of Proposed Closed-Cycle Schematic
41	Apr. 5, 1945	Strain Gauge Preamplifier
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63	Sept. 18, 1945	Conference Notes On discussion of methods to handle take-off and landing, stall representation, compressi- bility effects, cockpit instruments, engineer's panel, center of gravity, cockpit motion, vibration, and noise.
64	Oct. 31, 1945	Equations for Aircraft Flight Revised and expanded, April 4, 1946
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78	Mar. 25, 1946	Frequency Modulated Servo System Report on power stage circuits.
79	Mar. 9, 1946	Frequency Modulated Servo System Design and test characteristics of the servo motor.
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81	Mar. 7, 1946	Frequency Modulated Servo System Mathematical analysis of servo system.
82	Jan. 21, 1946	Frequency Modulated Servo System Phase-sensitive detector stage.
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94	Feb. 12, 1946	Some Psychiatric Observations on Cockpit Design by Dr. Holder of Massachusetts General Hospital
95	Dec. 7, 1945	Noise Level Test Rack Amplifier Tests
98	Mar. 7, 1946	Constants and Curves for a Twin Engine Airplane (called Model A) for Analyzer Equations. This is a set of constants and non-linear coefficients for a typical airplane as des- cribed by the equations in Report R-64 (Appendix A.)
99	Apr. 4, 1946	Design of the Mechanical System for Transmitting Control Forces from the Loading Equipment to the Cockpit Controls
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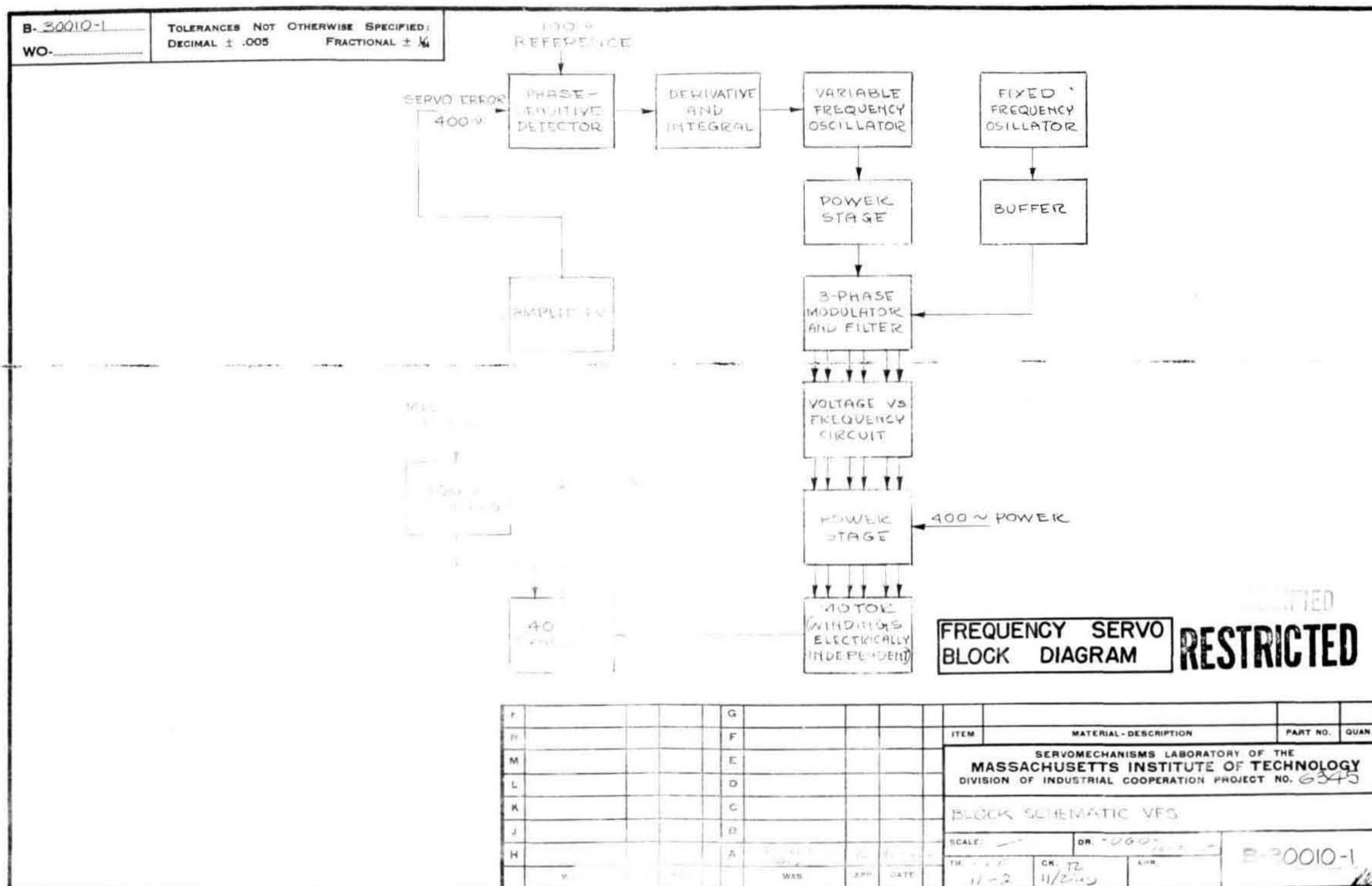
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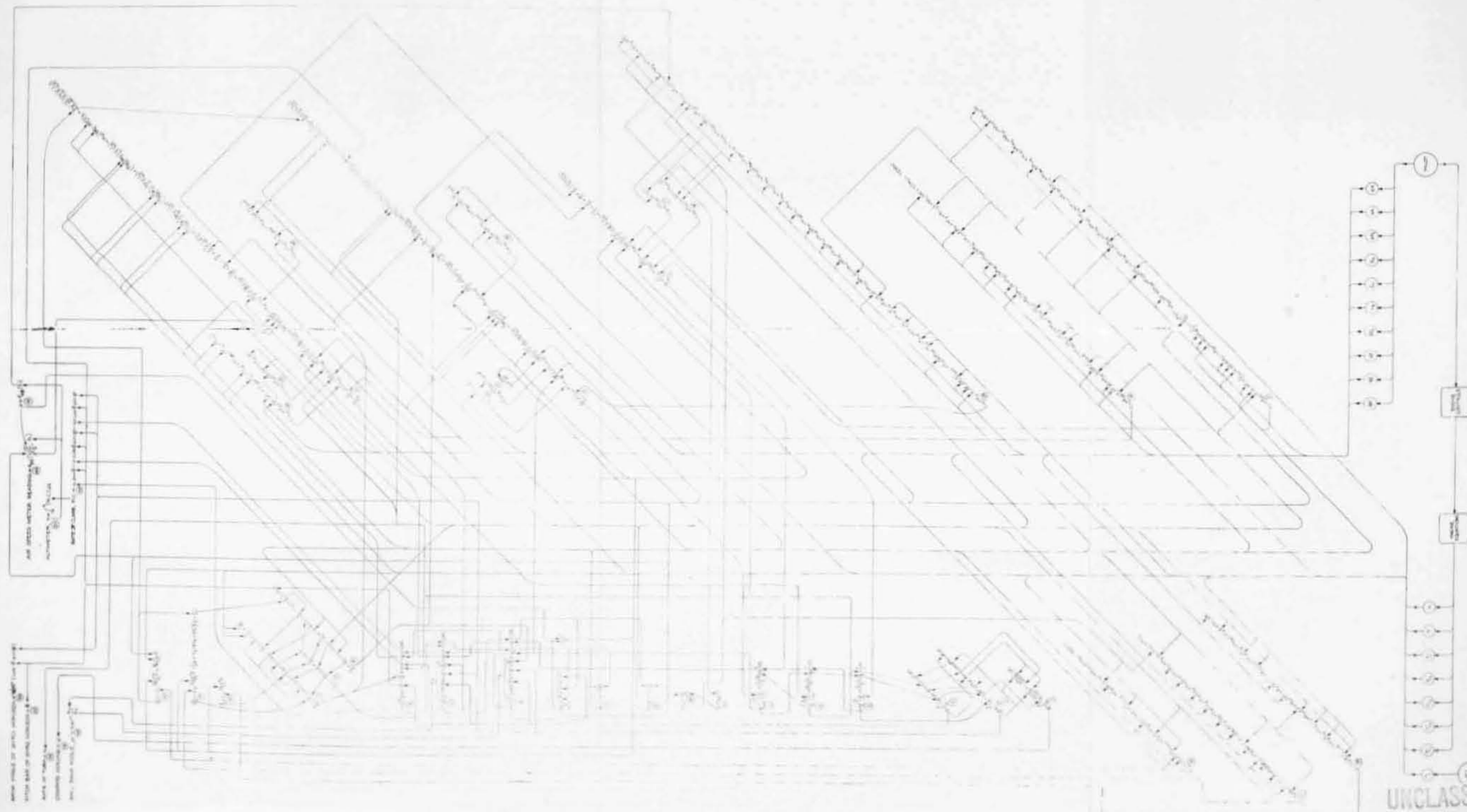
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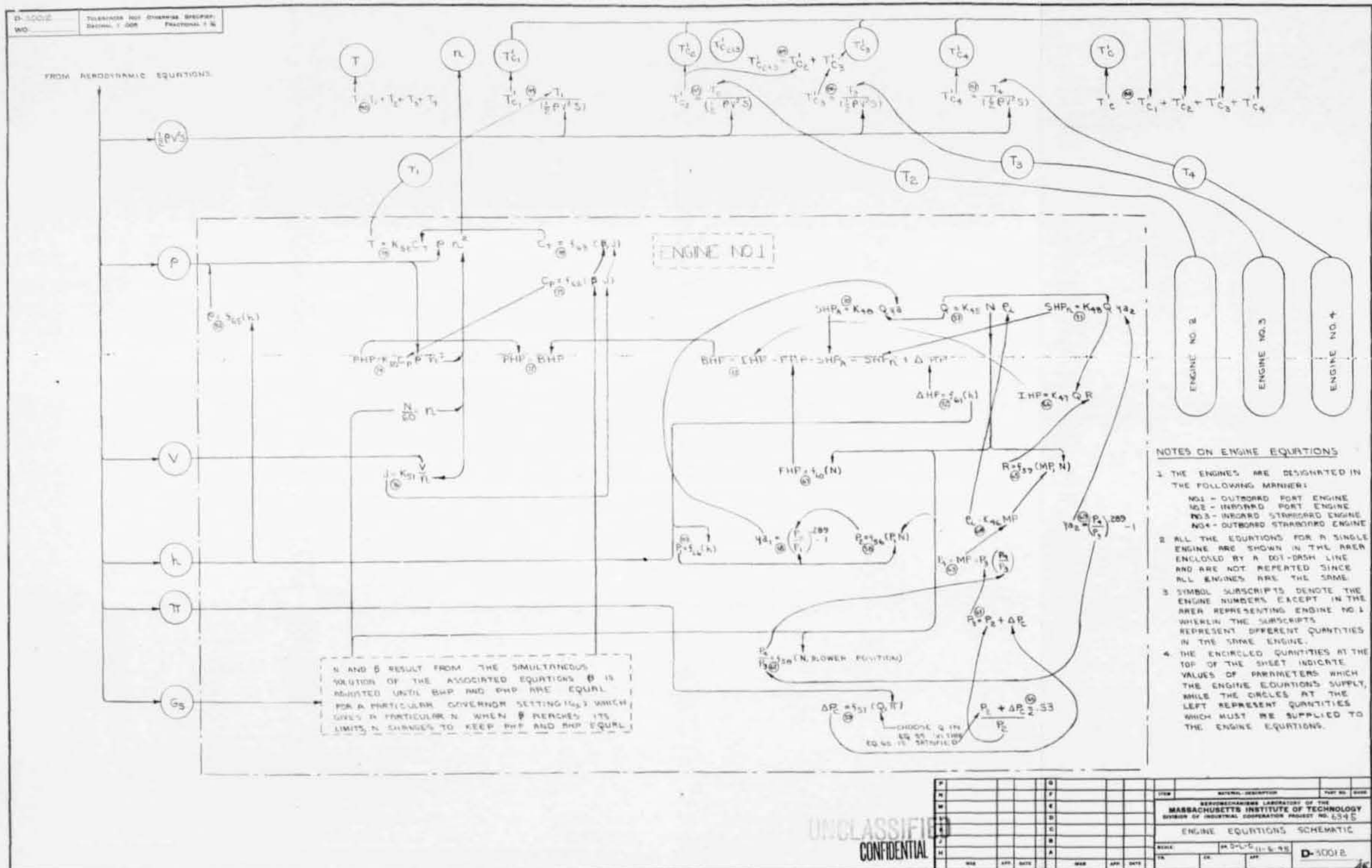
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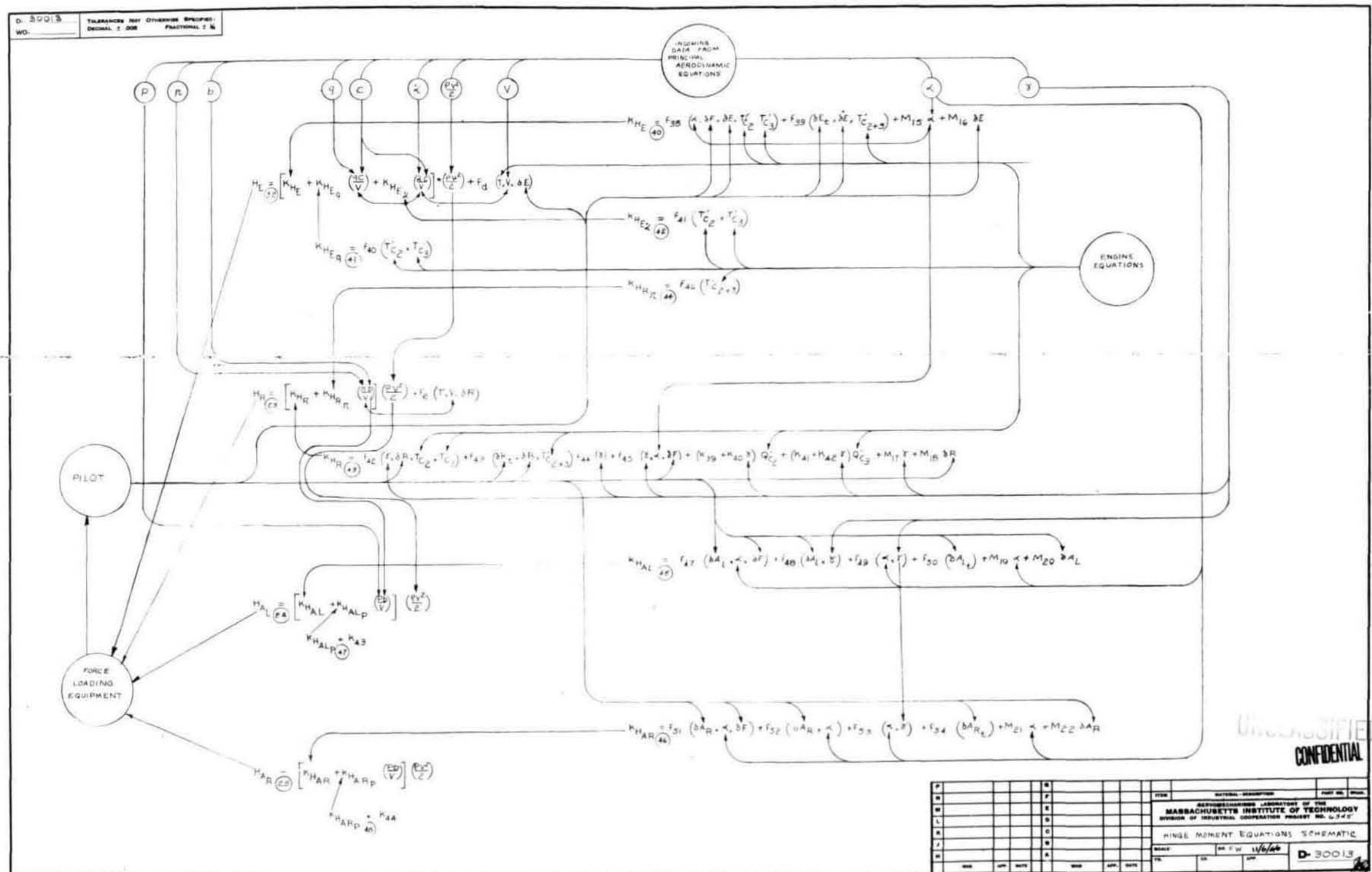


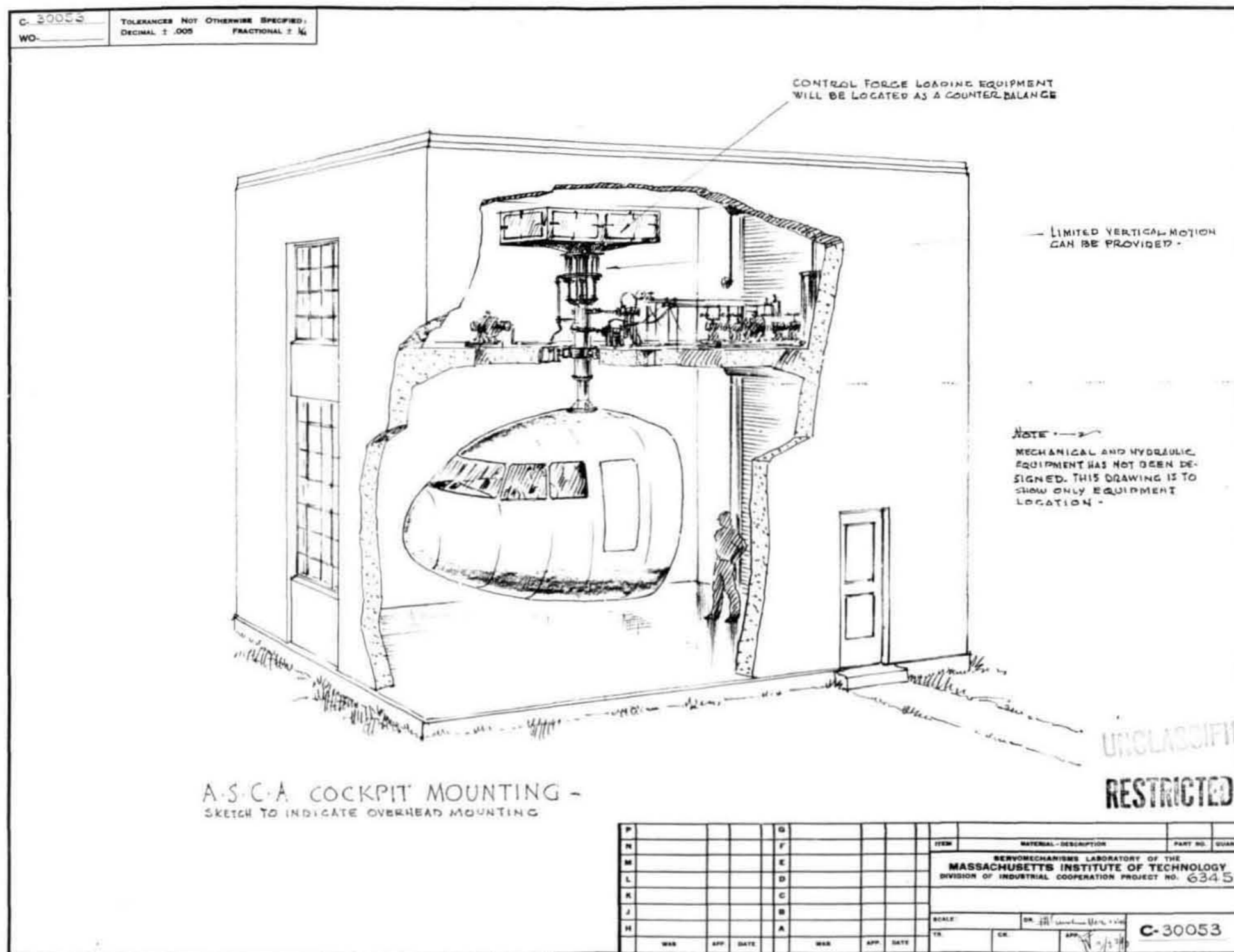


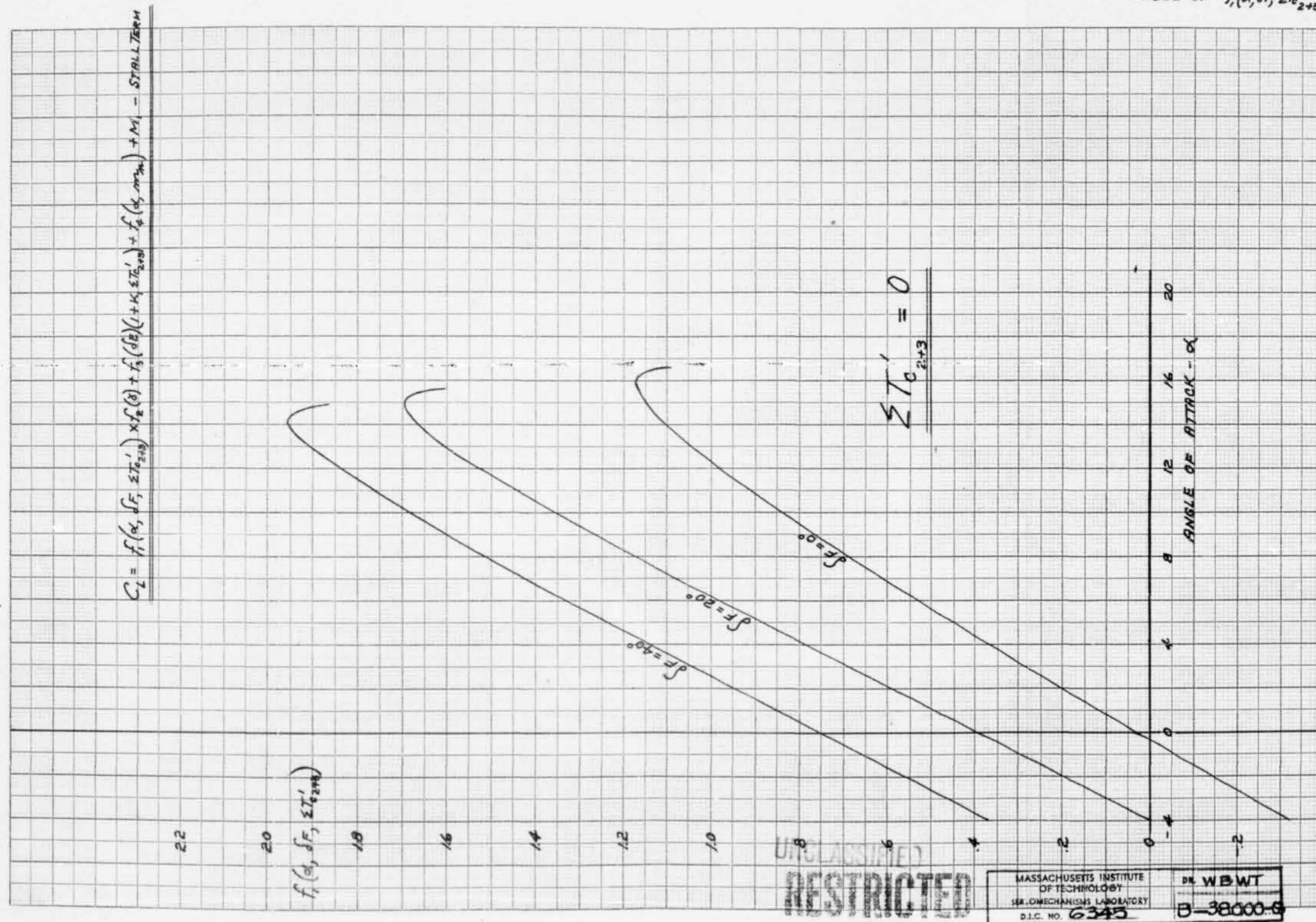
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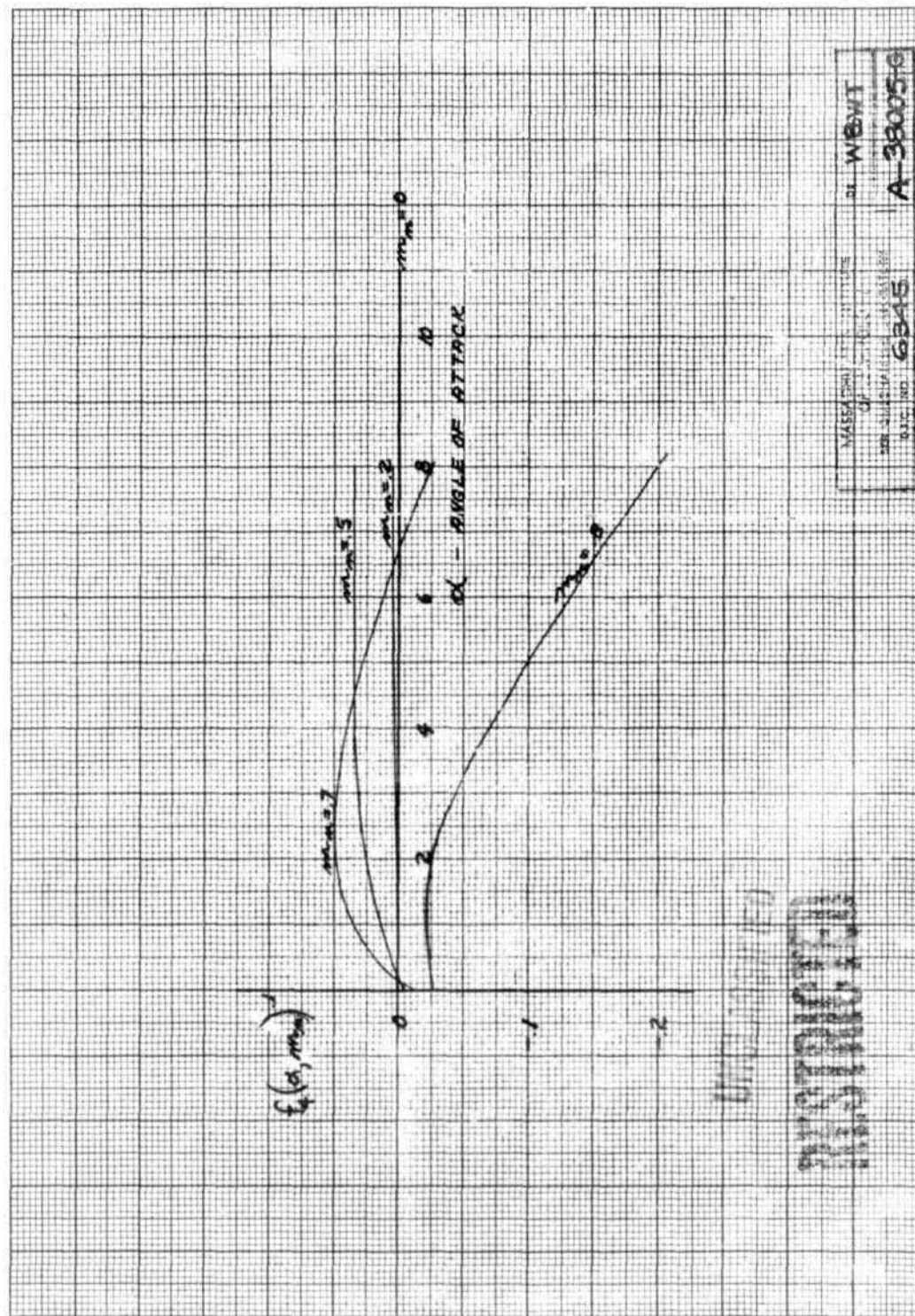




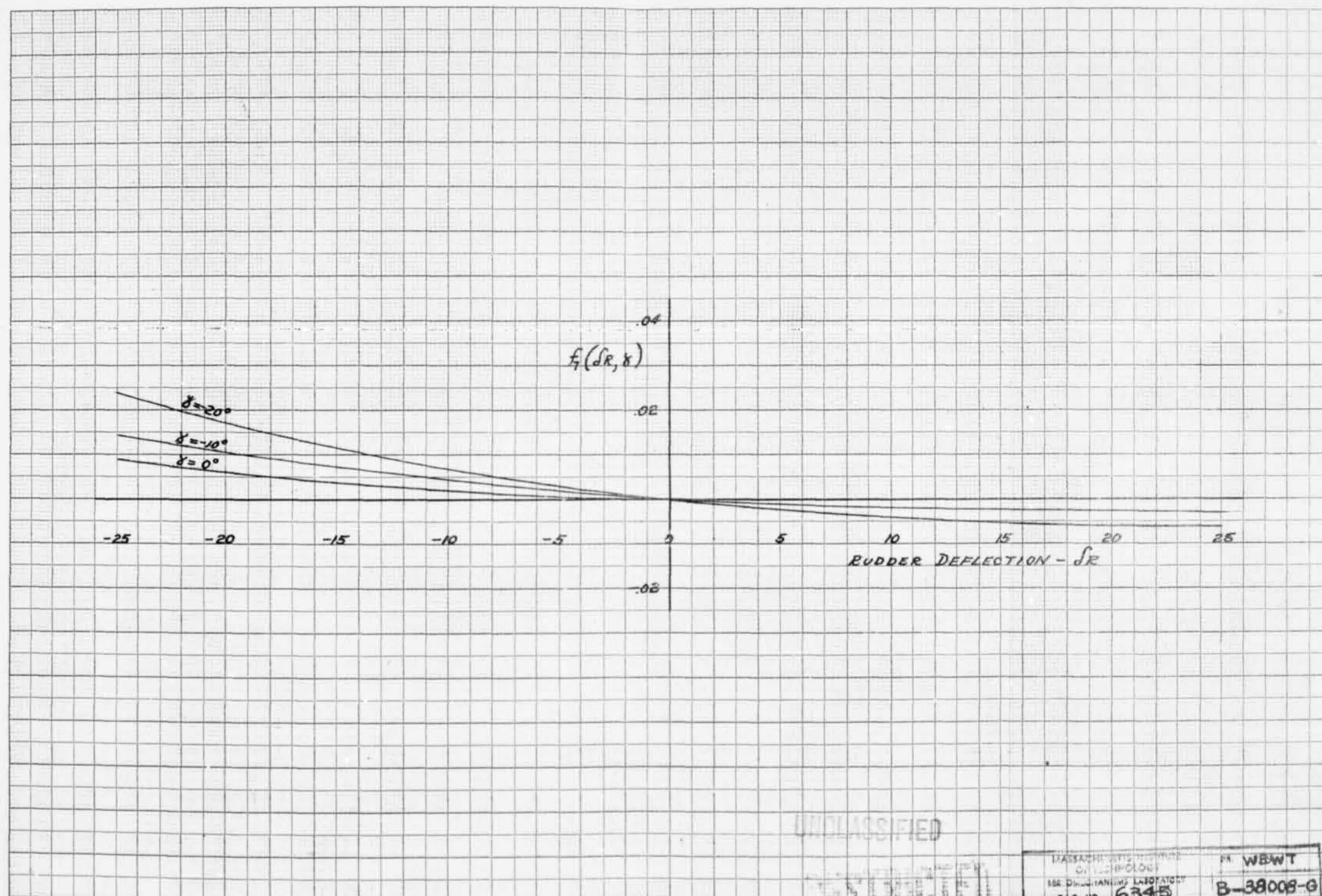




$f_4(\alpha, m_m)$



$f_7(\delta R, \delta)$



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